SCIENCE TEACHER'S WORLD

Teacher's edition of Science World • April 7, 1959

Student science squads

■ One of the most important ways a science teacher can create an abiding interest in science is through the use of student talent in the daily operations of the science classroom or laboratory. And one of the tried-and-true methods of doing this is the science squad. Most teachers already have students who help in many small ways, such as in preparation and clean-up. Usually, however, this is done on a rather informal basis. By the setting up of science squads, individual students can be assigned those responsibilities that best tap their particular talents. The work can be done before school, after school, and during study periods. This not only stimulates interest in science but also relieves the teacher of many small routine details, conserving his energy for his main function of teaching science.

It is wise to make the squad a formal organization so that students can receive service credit on their school record. In some schools a science squad is chartered as a regular extracurricular club or activity by the student general organization. Identification buttons, emblems, or armbands help to set up an *esprit de corps*. In schools that have such science squads, students vie for positions on them.

Now let's look at the many ways a science squad can be put to work.

One pressing piece of business in science teaching is the daily preparation of apparatus. Some of the squad members can get the items from their storage places for the teacher. (This means, of course, that some students must be taught the location of the equipment.) To make this job run smoothly, the teacher should prepare in advance a list of the items required for each day's experiment. This can take the form of a small sheet of paper or card, which is posted for each grade (or science subject) on a special small bulletin board. The same squad members can take apart and clean the equipment at the end of the day, returning it to storage.

Other squad members can service the bulletin board, keeping it up-to-date with materials clipped from newspapers and magazines. At the end of the day, yet others can be held responsible for a general clean-up of the science room and the preparation room, if there is one. Squad members should be instructed in the safety and fire regulations and should be taught how to use the fire extinguisher. Give them a short test on safety regulations at regular intervals.

Operation of projectors (slide, filmstrip, sound, etc.) is a very important way in which squad members can help the teacher in classroom routine. Naturally, this requires training, but the time invested is well recompensed. If a projector is run by well-trained students, the teacher is relieved of the physical burden of operating it during class time.

Other students on the squad who are artistically talented can make charts, models, and slides.

If living things are kept in the classroom, still other opportunities open up. One group can be charged with the daily care of plants. Another group takes over the care and feeding of animals and fish, making sure the animals' cages are cleaned every day.

Students can take charge of the classroom science library, including the magazine rack. They should keep records of the books and magazines borrowed, and they should inform the class of new publications available. The same group might also take on the cataloguing and storage of teaching charts.

Many squads publish their own mimeographed science bulletins. In connection with this, there's no reason why a teacher with mimeographed class material to prepare shouldn't draw on student skills for cutting stencils and running the mimeograph machine.

Tutoring is a possible activity for squad members who are superior students. They can be assigned to work with members of their class who need help.

On the less demanding side, a reading group can look for articles in current publications that pertain to the topic under investigation in class. They can present digests of these articles to the class as a whole.

Provided it is safe, interested and skilled students can be enlisted to help the teacher gather living materials for general science and biology classes.

Last — but far from least — is the checking out and in of materials and equipment for laboratory work. For example, if microscopes are being used, they can be distributed by squad members, along with the necessary slides, medicine droppers, etc. It's a good idea to stop

STW Contributing Editors: Alexander Joseph, Zachariah Subarsky

experiments or lab work about six minutes before the end of a period so that the squad members can collect the equipment, check it off, and clean up. During this time, the teacher is free to give a summary or answer student questions.

Obviously, there are more squad activities listed in this article than any one teacher may want (or need) to tangle with. You will want to choose only the activities that would be most helpful to you, and you will never want more than six squad members working in your room at any one time. However, this last factor may work out automatically, since squad work must be scheduled in relation to the time members have available in their school programs.

In general, though, the time a teacher devotes to setting up a squad and training the members will be returned a hundredfold. A good squad makes classroom life less hectic, more pleasant, and considerably more efficient. Furthermore, squads can be self-perpetuating when senior members train younger members, thus insuring continuity from school year to school year. — ALEXANDER JOSEPH

Science teacher's

QUESTION BOX

I have difficulty growing plants on a window sill that receives little sunshine. Which plants would thrive best under these conditions? — R. M., New York, N. Y.

Plants that will do well on window sills receiving two to three hours of sunlight daily include: African violet, begonia, coleus, peperomia, and spider plant. For windows with a northern exposure (no direct sun), the following are suggested: begonia, Boston fern, Chinese evergreen, date palm, grape ivy, English ivy, philodendron, snake plant, tradescantia, and live-forever.

I have been using litmus paper and phenolphthalein as indicators for acids and bases for many years. What are some other good indicators? — S. W., White Plains, N. Y.

Here is a rather complete list of commonly used indicators. Some of them can be obtained from drugstores. Chemical supply houses carry all of them.

1. Brom cresol purple — yellow in acid, purple in base.
2. Brom thymol blue — yellow in acid, blue in base.
3. Phenol red — yellow in acid, red in base.
4. Neutral red — red in acid, yellow in base.
5. Cresol red — yellow in acid, red in base.

Where can I get a list of free or inexpensive science teaching materials? — B. H., Belmont, Mass.

Write to Science Clubs of America, Science Service, 1719 N St. N.W., Washington 6, D.C. Ask for the "Sponsor Handbook." The price is $1.

Payments of twenty-five dollars will be made to contributors whose material is used in "Shop Talk" (see p. 7-T). Won't you send us news of unusual classroom experiments, problems, or triumphs?

Please send contributions to: Science World Shop Talk, 575 Madison Avenue, New York 22, N.Y. The editors regret that they cannot acknowledge or return unused contributions.

MEMO

To: Science teachers

Subject: Ways to use this issue of SCIENCE WORLD in the classroom

Electrical 'farm'

PHYSICS TOPICS: photoelectricity, electric power
EARTH SCIENCE TOPIC: the moon
GENERAL SCIENCE TOPICS: electricity, energy cycle, the moon, space travel

Here is an article that can set the imagination soaring. At the same time, it provides a solid scientific foundation for "imagineering." Before students read the piece, the teacher might well fill in the background — what we know about the moon, including the near-vacuum that surrounds it. It is this near-vacuum that may make possible a lunar power station such as the article describes. It also might be well to review with the class some simple photoelectric effects. In reading the article, students should carefully follow the ways in which human needs might be satisfied on the moon. Although the article is based on sound scientific fact, it has the visionary appeal of science fiction.

Discussion questions

1. How would electric power be produced in quantity on the moon?
2. How would water be made on the arid moon?
3. What basic scientific principles underlie Dr. Castruccio's proposals?
4. How would men work freely on the moon?

Projects and experiments

1. Use a simple photographic exposure meter to show light being converted into electricity.
2. Connect a solar battery or photocell to a galvanometer or milliammeter to show that light energy can be converted directly into electrical energy. Solar batteries are sold by large radio supply houses at a price under $2. If possible, hook up several solar batteries in series and use them, in place of the small transistor battery, to operate a transistor radio receiver. Large radio supply companies also sell small kits for making transistor radios operated by solar batteries.
3. Have students report on the use of solar batteries to operate the radios installed in man-made satellites.

YOUNG SCIENTISTS

Teachers are urged to have their students submit write-ups of interesting projects or experiments they have done. If printed in SCIENCE WORLD, full credit will be given to the student, the school, and the teacher. In addition, the student will receive $15. Contributions should be addressed to Science Project Editor, Science World, 575 Madison Avenue, New York 22, N.Y. Students should be reminded that by submitting their ideas they can do a service to thousands of other students.

The vertical laboratory

BIOLOGY TOPICS: ecology, plant and animal life in different climates
GENERAL SCIENCE TOPICS: vegetation and animals on mountainsides

This readable article takes the reader on a trip up a mountain, giving him a cross section of plant and animal life in the different altitude zones, from subtropical to subarctic. It is must reading for all biology and general science students. The article should serve to enrich the classwork and to round out the textbook. If there are mountains that are easy and safe to climb in your area, students may be stimulated to do their own ex-

plorations of the changes in plant and animal life at various altitudes.

Discussion questions

1. How does plant and animal life vary at different altitudes?

2. How does the amount of water available determine the spacing between plants?

3. What is the natural history of the Chiricahua Mountains?

4. What equipment do biologists use to study the plants found in different climatic zones on the mountain range?

Class projects

1. If possible, take the class on a trip up a mountain to study plant and animal life at different levels. Students should take photographs and, if it is permitted, make collections. They might make a chart of the mountain and indicate by drawings the types of plants and animals to be found at different altitudes.

2. Have students compare the root systems of plants that normally live in dry soil with those of plants that normally live in wet soil.

New tasks for silent sound

PHYSICS TOPICS: ultrasonics (frequency, velocity, and wave-length relationships)

GENERAL SCIENCE TOPICS: sound, generating and receiving sound waves

In this article, a well known physicist and science writer explains ultrasonics in a way that physics and general science textbooks do not ordinarily do. The article can be used to round out the textbook and classroom teaching in the field of sound. It carefully differentiates between audible and inaudible sound. In addition, it describes many new applications of ultrasonics — applications in research, in manufacturing, and even in housekeeping.

Discussion questions

1. How do ordinary sounds differ from ultrasonic sounds?

2. What is the frequency range of the average human ear?

3. What is the difference in the way audible sounds and ultrasonic sounds are produced?

4. What are some applications of ultrasonic sounds in everyday life?

5. How can ultrasonics be used to operate a shop tool?

Class projects

1. Use a Galton dog whistle to demonstrate ultrasonic sounds. You can show that a dog responds to the whistle when its frequency is so high that the sound is no longer heard by human beings.

2. If you have or can borrow an audio-signal generator and an oscilloscope, operate them in conjunction with a loud-speaker so that the class can first see the audible sound waves on the screen of the oscilloscope and then hear the sound. As the signal generator is adjusted beyond the 20,000-cycle range, the students will no longer hear the sound. But they will still see the evidence of the high-frequency wave patterns, which will continue to appear on the screen of the oscilloscope.

Giant meteorites

PHYSICS TOPIC: collisions and the conservation of energy

EARTH SCIENCE TOPIC: solar system

GENERAL SCIENCE TOPICS: meteors and meteorites

Most textbooks in earth science and in general science take up the subject of meteorites and meteors. But the material is often rather dated and incomplete. This article will fill the student in on some of the details and on more recent discoveries. For example, it describes theories about the origin of giant meteors. It also tells about the recent discoveries of giant meteorite craters in Siberia and in the arctic regions of Canada.

Discussion questions

1. What are some of the many theories about the origin of giant meteors?

2. Where have giant meteorite craters been found in Asia?

3. How were the giant Canadian craters discovered?

4. What is known about the orbits of meteors?

Class projects

1. If a local natural history museum has meteorites on display, take the class on a visit to it.

2. Small meteorites are sold. If you can get one, pass it around the class. If it is metallic, test it with a magnet. The magnet will attract it, since metallic meteorites are mainly composed of nickel and iron, both of which are magnetic materials.

3. Using a map of the world, have students pinpoint the location of giant meteorite craters.

They hunt the smallest game

BIOLOGY TOPICS: viruses, insect vectors

GENERAL SCIENCE TOPICS: health, fighting disease

In this article, the students are able to share, vicariously, the experiences of virus hunters in what appears to be a gold mine of viruses. Readers also get a glimpse of the world-wide organization that fights disease and identifies new viruses before they spread on a large scale. This material should be used to expand the work on pathogenic micro-organisms covered in biology or general science.

Discussion questions

1. How do birds facilitate the spread of viruses?

2. What part do insects play in the spread of virus diseases?

3. How are new viruses located in infected human beings?

4. What is the purpose of the work of the Drs. Causey and Causey?

Class projects

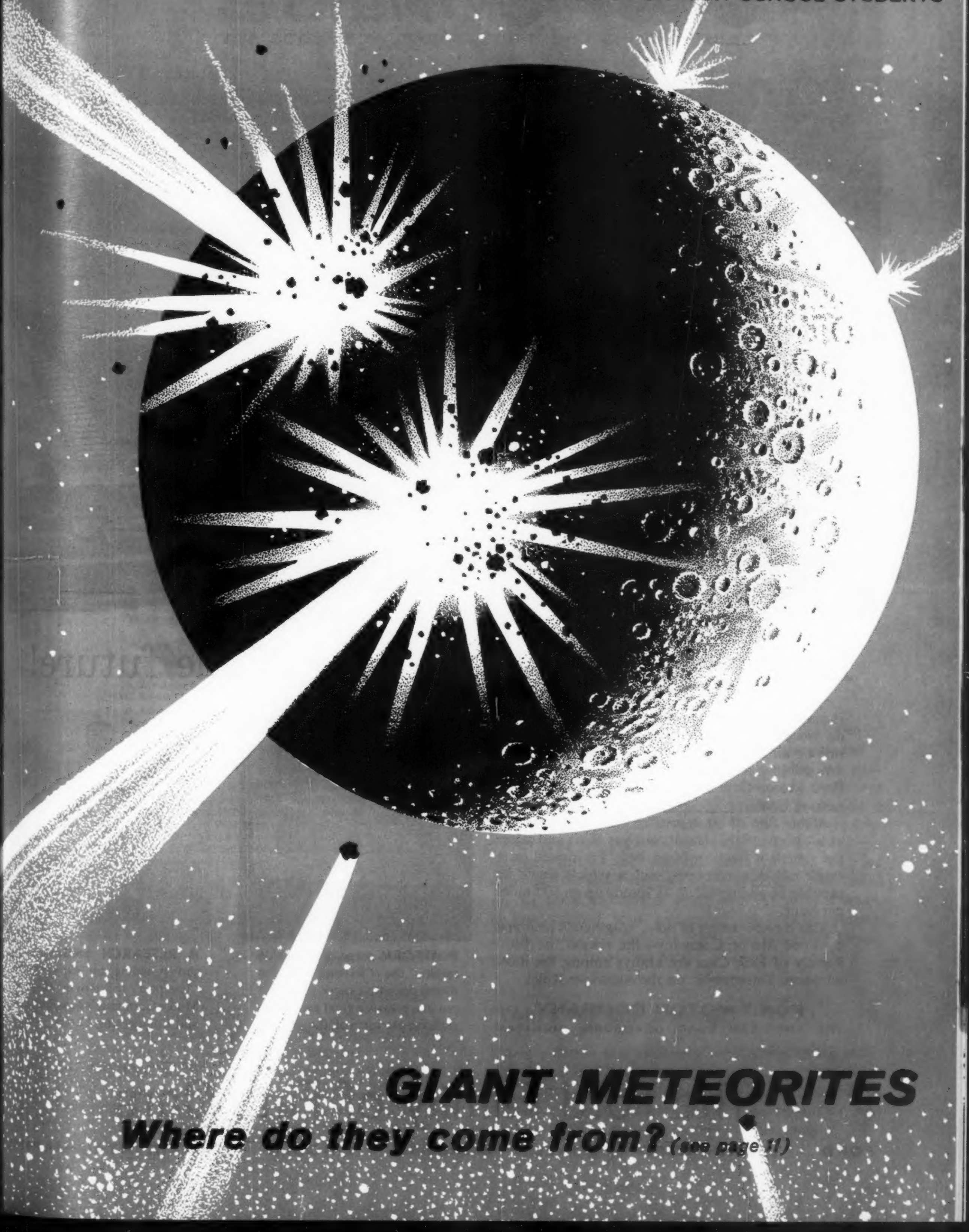
1. Have students prepare a world map, indicating the areas in which certain diseases are common.

2. If possible, obtain from a physician pictures of viruses taken through electron microscopes. These pictures often accompany advertising materials sent to physicians. If these are not available, virus photographs may be found in textbooks.

SCIENCE WORLD

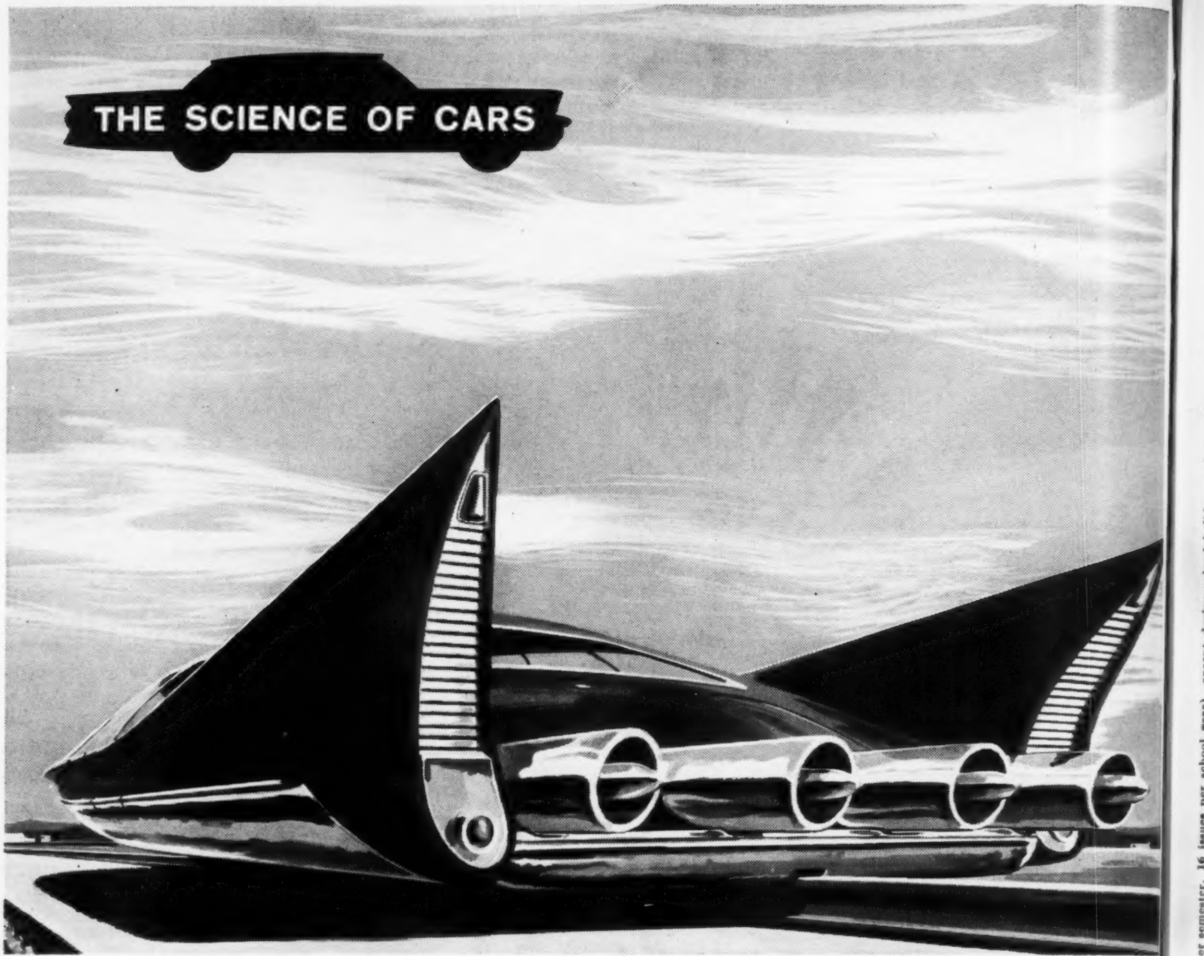
APRIL 7, 1959

THE SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS



GIANT METEORITES

Where do they come from? (see page 11)



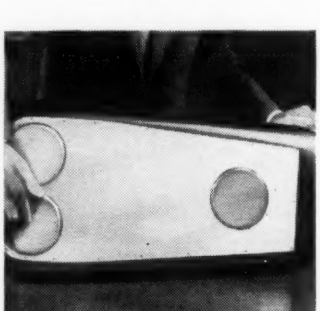
Look—no wheels on this car of the future!

It may well be that the cars of the future will have no wheels—not even a steering wheel. They will ride on air and be guided by a rail. At least that's a possibility engineers are studying right now at Ford Motor Company's new Research and Engineering Center.

A thin film of air is created by a device known as a "levepad" that shoots out jets of air and raises the vehicle a fraction of an inch. Positioned on a single rail by gyroscopes, such a vehicle would be capable of gliding along at speeds up to 500 miles per hour.

This is one example of bold, imaginative planning by Ford Motor Company—the reason the Ford Family of Fine Cars are always among the most advanced automobiles on the American Road.

FORD MOTOR COMPANY
THE AMERICAN ROAD, DEARBORN, MICHIGAN



PLATFORM turned on its side reveals the "levepads"—three round discs that shoot jets of air out at a pressure great enough to raise the platform off the ground.

A RESEARCH ENGINEER is shown riding an experimental "levepad" platform at Ford Motor Company's new Research and Engineering Center.

The Ford Family of Fine Cars

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Coming in SW, April 21

What is current scientific thinking on the possibility of life on Mars? What are the implications of recent experiments with "Mars jars"?

What causes auroras? How do solar activities affect the earth?

Who was Roger Bacon, and what bearing does his work have on modern science?

What major obstacles had to be overcome in developing the Navy's new IRBM, Polaris?

For answers, see next issue of *SW*.

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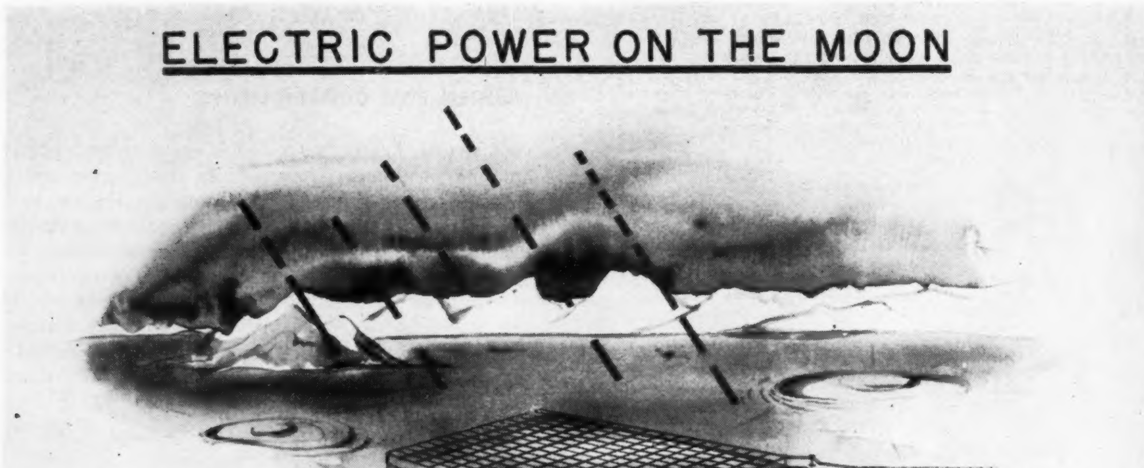
About the contributors

DR. IRA M. FREEMAN (p. 14) is associate professor of physics at Rutgers University in New Jersey and a science writer of considerable standing. He has written a number of highly successful science books for young people, as well as several technical books in the field of physics. JULES BERGMAN (p. 20) works in television news coverage, where his special interest is rockets and missiles. MURRAY MORGAN (p. 26) traveled some 28,000 miles in the course of gathering material for his book, *Doctors to the World*. At various times, he has worked at a variety of jobs, ranging from bridge-tender to editor. At present he is a radio broadcaster and a free-lance writer.

'Yours for the asking'

Please note the new address given for requesting materials listed in "Yours for the Asking" (p. 28). Your use of that address will greatly speed the handling of requests. However, all other *SW* mail should be sent to the addresses given elsewhere on this page.

MODEL OF LUNAR POWER STATION is demonstrated by Dr. Peter A. Castruccio. Diagram shows how it would work. A wire grid is placed just above a photosensitive sheet. When sunlight strikes sheet, electrons jump from sheet to grid.



By Edmund H. Harvey Jr.

Electrical 'farm' on the moon

The moon would make an ideal jumping-off place for interplanetary flight — if a self-supporting base could be set up on its surface. Here's how this might be done

■ Before man can travel to the planets, he'll probably have to build a station in space. There is good reason for this. A rocket must use up most of its fuel to break free from the bonds of the earth's gravity. This leaves too little fuel for interplanetary travel.

A man-made satellite station could serve as a refueling stop. It would whirl around the earth at an altitude of, say, a thousand miles. But the building of such a station would be a tremendous — and very costly — job. The station would have to be assembled piece by piece from parts ferried up by rockets. Fuel, equipment, and supplies would also have to be brought up piecemeal, along with construction workers.

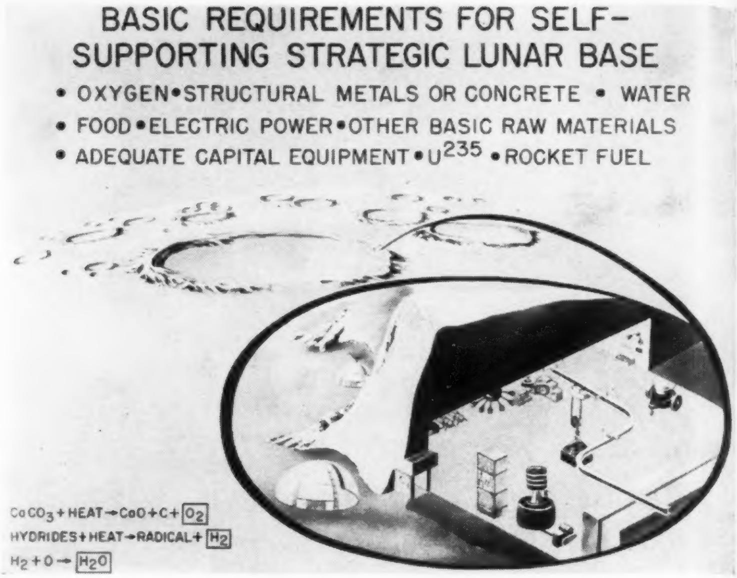
A better solution might be to build a station on the earth's natural satellite, the moon. For a lunar station might be made almost self-sufficient. Some scientists think the moon could be made to yield most or all of the materials and products needed to support an interplanetary space station. These would include oxygen, food, and water for the men running the station and materials for building shelters and equipment. Even rocket fuel and rocket-building materials might come from the moon.

How could all this be possible on a barren body that lacks water, air, life, and other earthly resources? The key is power. Given enough power, almost anything might be possible on the moon. But power from what? There are no fuels or water power available to generate electricity. And atomic power plants are costly and difficult enough to build on the earth, let alone on the moon.

There is one power-producing method, however, that seems promising. It's based on a plan worked out by scientists under the guidance of a far-sighted engineer named Dr. Peter A. Castruccio. He is head of the Astronautics Institute of Westinghouse Electric Corporation.

The Westinghouse plan hinges on a seventy-year-old scientific observation: under certain special conditions, the energy of sunlight can be converted directly into electrical power. This is called photoelectric conversion, or photogeneration. The one condition for photogeneration that can't be fulfilled simply on earth is a vacuum. But the moon is surrounded by a natural vacuum. "Using photogeneration as a source of power on the moon," says Dr. Castruccio, "seems like a lot better idea than trying to cart coal and water to the moon to run things on steam power."

The basic principle of photogeneration is simple. When light strikes a photosensitive material — one highly sensitive to light — electrons are jarred loose from the material's surface. These free electrons will jump to a nearby wire grid, generating a voltage. The photosensitive material and grid are con-



Shelters on the moon might be dug out of huge lips of lunar craters. Air-conditioned glass domes might be used for growing crops.

— Illustrations from Westinghouse Electric Corporation

nected in a circuit. As the voltage builds up, current can be drawn.

On the moon, huge sheets of plastic would be stretched and supported over several acres of the lunar surface. The plastic sheets would be coated with a thin layer of photosensitive material, probably a metallic mixture. Above and facing the sheets would be a wire screen (see diagram, p. 4).

"As the rays of the sun strike the plastic sheet," Dr. Castruccio explains, "the chemically treated surface will emit electrons. These will be collected by the wire mesh. This process creates an electric voltage that will exist as long as the sun shines on the surface. You could call the whole thing a kind of electron farm." One acre of such a "farm," he estimates, would yield enough electricity to light 20,000 sixty-watt bulbs or power 10,000 television sets. How many acres would be needed to power a lunar station would depend on many factors now unknown.

Photogeneration equipment has two virtues that make it ideal for supplying power on the moon. Since it is very light in weight, it would be easy to transport from the earth by rockets. Furthermore, its truly simple construction makes the "power plant" practically indestructible. Suppose, for example, that a meteorite ripped a large, jagged hole in the middle of the plastic film. The generator's electric output would be reduced only in proportion to the size of the area destroyed. And the damage could easily be repaired.

Eventually, Dr. Castruccio foresees an interconnecting system of photoelectric power plants, capable of supplying power at any time to any point on the moon's surface. Thus continuous electric power would be assured throughout even the fourteen-day "nights" on the moon. This would open up a whole range of possibilities for making the lunar station more or less self-supporting.

Suppose, as an example, that the lunar surface proved abundant in silicon compounds similar to the sand and quartz that are so common on the earth. These compounds contain oxygen, which could be extracted by heat. The oxygen could be pumped into shelters dug out of a lunar mountain and into huge glass domes to provide an earthlike atmosphere. Within these shelters and domes, heated and cooled by electricity, man could work as freely and effectively as on the earth.

If hydrogen compounds were also present the hydrogen could be combined with oxygen to form water. Inside the domes, food could be grown, without soil, in a water solution containing the necessary nutrients.

Dr. Castruccio thinks it likely that the moon could be made to yield a number of potentially usable materials. The problem would be to find ways of developing them into useful products.

Once the moon station became self-supporting, it would make an ideal interplanetary station. The pull of lunar gravity is very feeble, and there would be no air drag to speak of. So a spaceship would burn little fuel in blasting off from the moon. The moon station could also serve as a scientific observatory and possibly as a strategic military base and as a mining center.

To Dr. Castruccio, planning for space travel is an exciting adventure. And he certainly is no stranger to adventure. Son of an Italian diplomat, he was studying at the University of Genoa when

World War II broke out. The Germans soon came down and started hauling students out of the university to serve in the army. Rather than be forced into the German regular army, he enlisted in a military engineer's outfit. Almost simultaneously, he set up contact with British Secret Service agents in Italy. Within months, he had successfully carried out two "impossible" missions. Both involved getting detailed top-secret maps of German-fortified lines.

While on a third mission, in January, 1945, he was spotted by an informer, arrested by the German SS, and sentenced to death by a firing squad. His execution date, postponed several times, was finally set for April 24, 1945. But time was running out on the Germans, and the Allies were sweeping toward the little Riviera town where he was imprisoned. On April 23, the Germans decided to move him and fellow prisoners by bus to a nearby, but safer, town. When an Allied plane strafed the bus, the prisoners tried to escape, but were caught. A German officer lined them up in a field to be shot, then unaccountably changed his mind and set them free. Perhaps he thought there was no point in killing them since the war was almost over.

After the war, Peter Castruccio returned to the University of Genoa. In 1946, he received his Ph.D. *summa cum laude* in engineering. He was then twenty-one years old, the youngest person in Italy's history ever to receive such a degree.

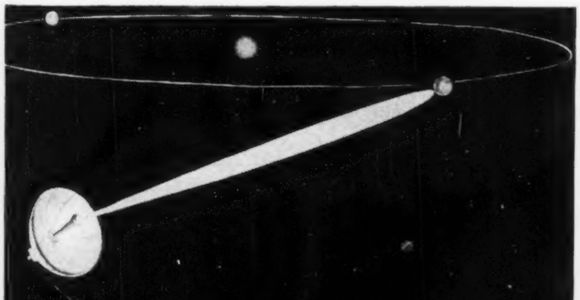
He subsequently came to the U.S., where he worked on various military missiles. He joined Westinghouse in 1955 and became director of the Astronautics Institute when it was formed last year.

Right now, Dr. Castruccio is involved in almost every conceivable aspect of man's venture into space. The moon power station comes under the heading of environmental control. But there are at least six other general areas of space investigation: propulsion, guidance and communications, navigation, space "mapping," auxiliary power units (to supply lighting, for example, inside a spaceship), and human factors in space travel. Each of these areas presents its own unique problems to Dr. Castruccio and his staff.

Take space navigation. With the tremendous speeds and vast distances of space travel, even the slightest miscalculation during launching can mean missing a final destination by thousands of miles. For example, an "aiming" error of 1 per cent in launching a rocket towards Mars would make the rocket miss that planet by some 500,000 miles. This, of course, assumes no correction, human or electronic, after the rocket is in flight. Even so, there are plenty of chances for error.

Narrowing the margin of navigational error is a chief goal of engineers at the Astronautics Institute. One of the most promising ways of doing it, they feel, will be to develop a "beam-rider" system for spaceships. This would be similar in principle to the guidance systems in certain missiles, such as the Navy's air-to-air Sparrow, which "ride" a radar beam to the target.

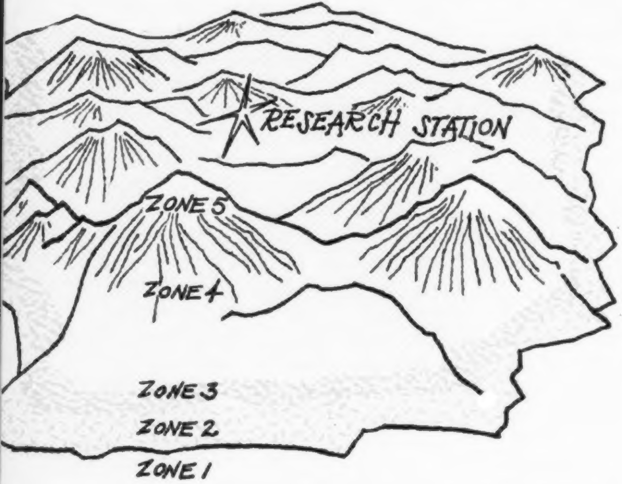
Now that the U.S. has succeeded in sending a probe past the moon, it should soon be possible to explore further the idea of a self-sufficient lunar station. Naturally, Dr. Castruccio and his associates are already working on this. They're investigating ways in which an unmanned probe or satellite could determine what materials are present on the moon and what their properties are.



TO COMMUNICATE over vast distances, spaceship might eject and inflate a large antenna in space, says Dr. Castruccio.

OPTICAL PROJECTION SYSTEM might guide ship. When on course, it would receive white signal; off course, color signal.

FIVE LIFE ZONES, each with distinctive plants and animals, are found in the Chiricahua Mountains.



— Map adapted from Natural History magazine by Wes McKeown

By Rose Wyler

The vertical laboratory

An amazing variety of plants and animals, ranging from subtropical to subarctic, are found in the short space of two miles, up and down, in a mountain range in Arizona

■ We drove from the subtropics to the subarctic in fifty minutes. Such a trip northward would have covered a few thousand miles. But we were traveling vertically, from plain to mountaintop. The route began in the desert of southeastern Arizona, near the Mexican border, then followed a canyon road up the Chiricahua Mountains to a peak almost 10,000 feet high.

This beautiful range, with its steep slopes and narrow passes, was once the stronghold of the Chiricahua Apaches. Now most of the million-acre tract is a wildlife preserve called Coronado National Forest.

Our main interest was in the natural history of the region. There probably is no area of equal size in the United States that has so many different species of plants and animals. From the desert to the heights lie several climate belts, one above another. Each makes a distinct life zone, with its own type of plant and animal community.

The first zone, surrounding the mountains, is an extension of the Mexican Plateau. Its vegetation consists mainly of desert grasses and cacti. In the last and highest zone, the chilled air of the mountaintops releases enough rainfall to support fir and spruce forests resembling those of the Hudson Bay region. Traveling upward is like traveling northward. A thousand feet vertically is roughly equivalent to about 300 miles horizontally.

My husband, our two teen-age boys, and I were camping in the National Forest and doing a little exploring in each zone. The Chiricahuas are such a wonderful place for field work that the American Museum of Natural History conducts a "permanent expedition" there. The base of operations is the Southwestern Research Station in Cave Creek Canyon, which was our first destination. We wanted to meet some of the scientists at the station, learn about their work, and get information about trails through the different life zones.

The scientists come from all parts of the United States and from foreign countries. Dr. Mont A. Cazier, the director, explained that many bring along their families. Others — teachers — bring students who attend classes and assist in research. A hundred or more people may be living at one time on the 54 acres of station property.

Generally, the group includes biologists, meteorologists, geologists, and astronomers. A few are staff members from the Museum in New York. But most of the scientists are guests who stay for varying lengths of time, working on their own projects. In many cases, these are supported by foundations, universities, or Government agencies.

Work is facilitated by the Osborn Memorial Laboratory, which houses extensive reference collections of regional plants and animals, an excellent library, and research apparatus. In addition to such standard items as animal cages, plant presses, and microscopes, equipment includes a number of unusual pieces, the use of

which is scheduled far in advance. The longest waiting list is for one of the few refrigerated Warburg manometricians in the country. This delicate instrument, with its intricate tubes, valves, and gauges, can measure the amount of carbon dioxide exhaled by a single cell at any temperature from −29° Centigrade to 70°.

The adjustment of specimens to atmospheric conditions, ranging from tropical to polar, can be studied in climatizers that look like ovens with glass portholes. For those interested in bird songs, mammal cries, or insect noises, there is a portable tape recorder with a pick-up device two feet in diameter, which can catch a whisper 300 feet away. Tapes are often played back to similar or closely related species to see if they will respond. In comparative studies of animal sounds, recordings are fed to a complex electronic device that transcribes them into visual patterns.

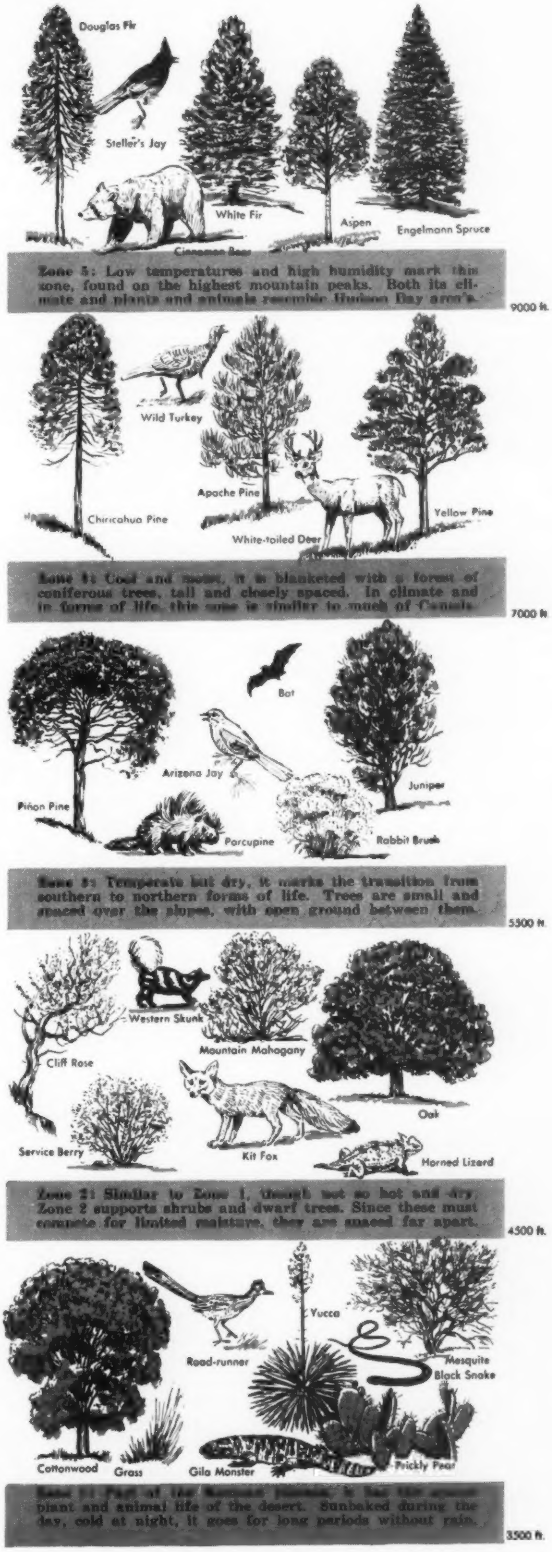
Most of the research of station scientists is carried on outdoors. The mountain slopes serve as a "vertical laboratory." Since the station is at the 5,400-foot elevation, any life zone can be reached in less than half an hour. And as an extra bonus, those who are interested in subterranean life can explore nearby Crystal Cave and try banding the bats that haunt its extensive passageways.

The majority of station projects are biological, and it is easy to understand why. On the property, 37 species of trees grow naturally, giving an indication of the great variety of plants in the area. The mountains abound with thousands of species of animals, including such rarities as the coati mundi, Mexican big-eared bat, and Arizona twin-spotted rattlesnake.

This profusion is partly due to the fact that the Chiricahuas are the northern limits of many tropical species, as well as the boundary of the range of many northern species. The mountains are also the meeting place of eastern and western species. Take birds, for example. The brilliantly plumed trogon of Middle America may turn up at the station along with a yellow-throated warbler, a native of the eastern United States.

Another factor is the isolation of the range, which rises like a land island above a vast desert sea. Many species have been stranded there. In the course of generations, they have developed into new types with unique mutations (hereditary changes). These fascinate geneticists. The scientists pursue unusual fruit flies in the area and compare chromosomes of paramecia from isolated water sources on different levels.

The most important factor in the abundance of species is the different climates. The life zones associated with them never occur in clearly defined bands, but merge gradually. In general, the same levels on opposing slopes have different vegetation, for the northern side is cooler and



— Illustrations by Matthew Kalmenoff, courtesy Natural History

wetter than the southern. Because strong winds come from the west, west slopes tend to have fewer trees than the east slopes. Adding to the complications are the animals that wander from zone to zone. To keep track of the movements of white-tailed deer, one researcher places colored salt at a given elevation. Deer eat this salt, which gives a color to their droppings. Pellets then show how far up or down the deer have moved.

The most comprehensive project now under way is Dr. Jack McCormick's three-year study of Chiricahua vegetation. He explained to us that he and his assistants will concentrate on one section. There they will examine the soil and plants in 300 sample plots — 60 in each of the five life zones. A list of the species and count of their numbers will be made in every plot. This data will then be compared with findings from the study of 300 more widely scattered plots. Finally, an estimate will be made of the plant population and distribution in each zone.

Dr. McCormick gave us many tips on what to look for in our own exploring. We began at the plateau in the desert zone, where rainfall averages less than 10 inches a year. Because of the scantiness of moisture, the plants are widely spaced. Clumps of long-bladed grasses, which form the main vegetation, obtain water by means of spreading roots. Other types of plants, such as the shrubs and mesquite trees that grow along the edge of washes, send their roots deep down into the soil in search of water. Their leaves are small — an adaptation that reduces loss of moisture. The cacti have gone to even greater extremes, dispensing with leaves altogether. Food-making is performed in their fleshy stems, which also store water.

Where plant life is sparse, animal life also is sparse. The most conspicuous of the animals are the birds. Magpies and meadowlarks fly about, while hawks soar overhead and road runners scoot along the ground. Lizards bask in the sun, but mammals avoid it by leading a nocturnal life.

At 4,500 feet, zone two starts. This is the chaparral belt of oak woodlands, which extends up to about 5,500 feet. Temperatures here are several degrees lower than in the desert, and rainfall amounts to about 20 inches a year. The lower slopes of the canyons are watered by drainings from above, which give them a thicker plant cover. Here we found several kinds of southwestern oaks, as well as the cliff rose, manzanita, and mountain mahogany. The birds kept us guessing, for many were similar, but not identical, to eastern species. We identified about a dozen kinds of lizards. Though typical of the desert, they also live in the open sunny stretches of the chaparral and of the next belt, the transition zone.

The transition zone is characterized by smallish piñon pine and juniper trees. Because of limited rainfall and quick run-off, the trees are spaced over the slopes, with plenty of open ground between.

At the 7,000-foot level, where the annual rainfall is about 30 inches, the Canadian zone begins. Here we found ourselves in the midst of a dense forest of ponderosa (yellow pine). We left the car here and went upward by foot. As we climbed, the air became colder, and the trees grew taller.

Reaching the 9,000-foot level, we entered the last and highest zone, the Hudsonian. This can be recognized by its magnificent stands of Douglas firs and spruces. Here and there were patches of quaking aspen, similar to those of eastern woodlands. But chill winds reminded us we were in a subarctic environment.

Buttoning our jackets and leaning against the wind, we clambered over a stretch of bare rock and came to the summit. We caught our breaths, for we seemed to be afloat over a vast empty land.

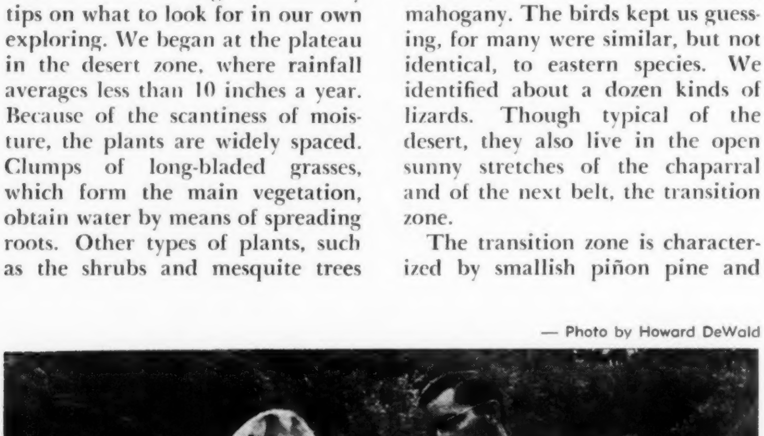
On all sides, the desert stretched out to the horizon, broken only by a few lesser ranges. Far below, we could pick out the various zones, layer after layer, rising up from the desert. Slopes with moderate rainfall were peppered with little dots — piñon pine and juniper. Above these, in the wetter zones, spread the dark, dense forest.

Streamers of mist began sweeping up the western slopes, and soon we were trapped in a swirling cloud. Scrambling down the trail, pelted by hailstones and deafened by crashing thunder, we reached the car at last and wheeled on downward. If only the dirt logging road would not be washed out!

As suddenly as the storm had trapped us, it let us free. We were in the blazing sunlight again, under the deep blue sky of the desert, while the storm raged in the distance.

That was one time we rushed through the five life zones in fifty minutes. And no sooner had we reached our camp beside the canyon road than the stream bed, dry before, was filled with a torrent, rattling over the stones and bringing water for the chaparral belt and the desert below.

— Photo by Howard DeWald



SCIENTIST 'SWEEPS' for insects along stream in Chiricahua Mountains. One entomologist said he had never done field work in an area that had so many forms of insects.

By Roy A. Gallant

GIANT METEORITES

These cosmic bombs occasionally strike the earth with enough force to level a city. Where do they come from?

On June 30, 1908, a cluster of huge meteorites crashed to earth in an uninhabited region of Siberia. So great was the impact that windows were broken fifty miles away. Within a radius of some twenty miles, hundreds of thousands of trees were flattened, their trunks seared by superheated air produced by the meteorites.

On February 12, 1947, a giant meteorite plunged into Russian soil, this time in the Sikhote Alin Mountains, north of Vladivostok. This meteorite may have broken apart before striking earth, or it may have been a cluster of meteorites. In any case, it ripped into the ground, leaving about 106 craters – the largest being 90 feet across. Two iron fragments weighing 700 pounds each were recovered from the 1947 meteorite; in addition, many smaller pieces of metal were found. The original mass of the meteorite has been estimated at from a thousand to several million metric tons. Had either the 1908 or 1947 meteorite struck a large city, there would have been little left except rubble.

Where do these giant meteorites come from? How were they formed? And is there a chance that one of these cosmic bombs will crash into one of our cities tomorrow, next month, or next year?

The fact of the matter is that nobody knows. But there are a number of theories about the origin and movement of meteors.

Many astronomers believe that giant meteors were born along with the solar system. Gerard Kuiper of the University of Chicago is one of these men. He feels that, when the planets were being formed, Jupiter's gravitational influence prevented a "normal" planet from developing in what is now known as the asteroid belt — which lies between Mars and Jupiter. Instead, possibly five or ten small planets were formed, none more than 650 miles in diameter. Eventually two of these midget planets collided; then others collided, breaking into rock and metal fragments, which we call the asteroids. Today thousands of these asteroid fragments sweep around the sun, just as the planets do. According to Dr. Kuiper, collisions among the asteroids are going on now and "will continue to produce many small bodies as well as additional larger ones."

Ralph Stair of the U.S. National Bureau of Standards also favors the planetary collision idea. He has studied many small, black-green glass meteorites called tektites. The tektites, he thinks, may be the shattered remains of two glass-skinned planets that once circled the sun

in orbits between Mars and Jupiter. One day, these twin planets collided; or possibly there was only one, and it collided with one of Jupiter's moons. In either case, such a cosmic crack-up would produce thousands of small bodies, together with many giant chunks of rock and metal measuring several miles in diameter. So the swarms of small meteors — together with the mile-wide giants that travel alone or in groups — may well have been born out of the violent collisions of two or more midget planets.

Some astronomers, however, feel that at least a few meteors may not be members of our planetary system. That is, they may reach us from deep space, having been formed in some distant part of the universe. If this is the case, they may sweep into the solar system for visits only. If there are such meteors, astronomers should be able to tell by plotting their orbits. A meteor reaching us from among the stars would have an "unclosed" orbit. Drawn into the solar system temporarily by the sun's gravitational attraction, it would complete its orbit far out in space. (A meteor that circles the sun has a "closed" orbit, as each planet has a closed orbit.) Whether or not there are meteors with unclosed orbits has been a touchy point among astronomers for years. For one thing, it's extremely difficult to plot the orbits of "sporadic" meteors (those that approach the earth unscheduled). The British astronomer A. C. B. Lovell reports that:

"Ten thousand orbits of sporadic meteors measured at Jodrell Bank by radio echo methods do not show a single case of an [unclosed] orbit. On the contrary, the majority of the sporadic meteors are moving in [closed] orbits with particularly short periods, that is, like some of the inner planets." But this question has yet to be settled once and for all.

Regardless of where and how the solar system's meteors originated, astronomers are keeping track of several giants that every now and then sweep in surprisingly close to our planet. S. F. Singer of the University of Maryland predicts that at least four giants may smash into us or some other planet one day. These are the "earthgrazers," asteroids with eccentric orbits. The earthgrazers measure from one to two miles in diameter. One of them, Hermes, sweeps within 485,000 miles of the earth on its closest approaches. If one of these flying mountains should crash into the earth, Singer says, it would carry the impact of 100,000 hydrogen bombs. But he assures us that there is no need to worry, at least not right away; it will take another 200 million years before gravitational forces of the nearby planets change the orbits of the earthgrazers in such a way that they will collide with us or with some other planet.

Have any of the asteroids or other giant meteors ever bombarded the earth in the past? The two Russian meteorite falls of 1908 and 1947, of course, are examples of just such a bombardment. And astronomers are beginning to find more evidence that our planet has long been a target for giant meteorites. One bit of evidence is the visible face of the moon. A look at the moon through even a low-power telescope will reveal hundreds of craters, some as large as 150 miles in diameter with circular walls stretching 20,000 feet above the lunar plain. Astronomers are convinced that at least some of the moon's craters were caused by a violent storm of giant meteorites sometime in the moon's early history. If this is so, it leads to an interesting thought:

Since the moon is so close to the earth, certainly our planet must also have been caught up in the meteorite bombardment. But if it was, where are the earth scars today?

Some investigators think that the earth's craters have long been disguised or erased by wind and water, or are grown over with vegetation — while the airless, waterless moon has preserved its craters. Another possibility is that the earth was still young and molten during the storm of giant meteorites; as a result, the meteorites sank into the soft crust like stones plunged into soft tar. Either of these explanations would account for the fact that the earth is not as "pock-marked" as the moon.

In recent years, evidence has turned up that the earth from time to time has been bombarded by meteors the size of mountains. The evidence comes from extensive aerial photography over Canada. Canadian scientists have found several giant craters, one measuring two miles across and about 200 feet deep. It is Brent Crater, located in Central Ontario. Rarely can such large craters be detected from the ground, because vegetation and erosion disguise them. Aerial photographs, however, make them stand out prominently. Once Brent Crater was found, geophysicists bored into it and proved that it was caused by a giant meteorite. Its

Glossary of terms

METEORS are stone or metal fragments that usually burn up on entering the earth's atmosphere.

METEORITES are meteors that survive the trip through the atmosphere and strike the ground.

Meteorites are divided into three broad classes: (1) the IRONS — called siderites — are made of a nickel-iron alloy (5 per cent to 10 per cent nickel; 85 per cent to 95 per cent iron); (2) the STONES — called aerolites — are like ordinary rocks, but usually contain metallic iron particles; (3) the STONY-IRONS — called siderolites — are sponge-like masses of iron with the spaces filled with rock materials.

BOLIDES are meteors that explode.

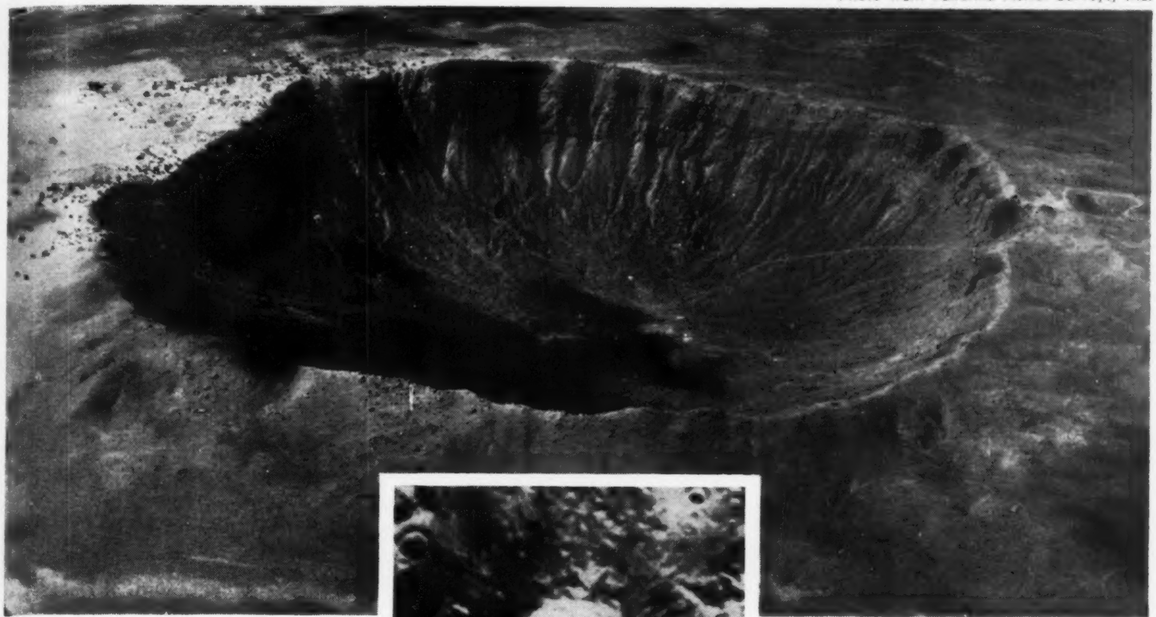
MICROMETEORITES are meteorites the size of dust particles that float to the ground.

SPORADIC METEORS are those individual meteors that are seen as "shooting stars" on nearly any night of the year.

SHOWER METEORS are those that appear periodically in swarms. They appear to radiate from certain constellations and are named accordingly — the Lyrids, the Perseids, Orionids, Leonids, etc.

TEKTITES are glassy fragments believed to fall to earth in clusters. They are thought to have originated within the planetary system, but there is little definite information about them.

— Photo from Fairchild Aerial Surveys, Inc.



— Photo from Lick Observatory

GIANT CRATER in Arizona (*upper photo*) was blasted out some 50,000 years ago by meteorite. Craters on moon (*lower photo*) are believed to be of similar origin. Due to an optical illusion, crater photos often appear as mounds, depending upon your view.

age, they think, may be about 500 million years.

After examining 400,000 aerial-mapping photographs of Canada, scientists have found a dozen possible ancient craters — one 20 miles in diameter. Canada's astrophysicist C. S. Beals says: "It seems that meteorite craters are a great deal more common on the face of the earth than was heretofore supposed. These ancient scars indicate that the earth has been colliding with large chunks of iron and stone from outer space throughout a great part of its history."

If this is so, what became of the great flying mountains? Shouldn't they be buried deep under the crater floors? Not necessarily, according to Dr. Beals and the American astrophysicist Ralph B. Baldwin. They say the giants, as well as small meteorites, are destroyed, though in different ways. Let's start with the small ones.

On any clear night you may see several small meteors plunging into the earth's atmosphere. Traveling at 18,000 to 162,000 miles an hour, few of them survive the journey to the earth's surface. Friction with the air at a height of 50 to 70 miles or so changes their energy of motion into heat and light. (You've probably often seen these thin trails of light.) They disintegrate, eventually floating to earth as dust. According to Dr. Baldwin, about a ton of meteoritic dust and solid meteorites fall to earth each day.

As for giant meteorites, Dr. Beals and others believe that they do survive the hot plunge through the earth's atmosphere (traveling at 36,000 to 72,000 miles an hour) but are destroyed on impact with the ground. They survive the trip through the atmosphere, because there is less air resistance in ratio to their mass than with the small meteorites. Yet they are destroyed on impact with the ground, because "an object moving at 72,000 miles an hour possesses energy equivalent to 65 times its weight in nitroglycerine," Dr. Beals says. In short, the giant meteorites become powerful explosives on contact with the ground. Chances are that part of them vaporizes and part shatters into tiny fragments. At the same time, their explosive impact pulverizes the earth material within the crater.

The great meteorite crater blasted in the Arizona desert floor about 50,000 years ago seems to bear out the idea that giant meteorites are destroyed on impact. Resembling certain craters on the moon, Arizona's measures about 4,100 feet from rim to rim. Around the crater are circular walls about 150 feet high; and the floor of the crater is about 570 feet deep.

Analysis of iron-nickel fragments found around this crater identified them as meteoric. But scientists are divided in their opinion of what happened to the bulk of the meteorite. Dr. Baldwin and Dr. Beals, of course, support the idea that such a meteorite would explode on impact; but others think that its mass still lies buried under the crater's southwest quadrant.

Removing 200 million years' accumulation of sediment from tiny marine fossils, cleaning delicate lenses, engraving metals — these are just a few of the

New tasks for silent sound

By Ira M. Freeman

■ How do you remove 200 million years' accumulated dirt and sediment from marine fossils too small to be seen with the unaided eye? This was the problem facing Dr. Gary Lane, a geologist at the University of California in Los Angeles. In addition, the dirt and sediment had, over the ages, hardened into shale.

Dr. Lane started by breaking up some of the shale and softening it. Then he turned to a new laboratory tool — "silent sound." He put the shale in a small tank of water and flicked a switch. Silent sound agitated the water at very high speed, and the microscopic fossils were scrubbed clean. Another proof was chalked up that some of the most interesting and useful of all sounds are the ones we cannot hear.

All sounds, both audible and inaudible, travel in the form of push-and-pull waves in the surrounding air, or in any other material — water or steel, for example. Dip a stick in and out of the surface of a pond at a regular rate, and waves will move out across the water in the form of ever-widening rings. Similarly, sound waves spread invisibly outward in all directions from any object that vibrates — swings back and forth — at regular intervals. The vibrating object may be a violin string, or perhaps a tuning fork or the narrow column of air inside a flute. Whatever the source, the sound waves streak away from it with a speed of about 1,100 feet per second — 750 miles per hour — at sea level.

The more rapidly the source vibrates, the closer the waves follow each other. Each complete wave has a "crest" where the air pressure is greatest, followed by a "trough" where the pressure is least. That means that at the compressions (crests) the air molecules are on the average slightly closer together than in normal air, while at the rarefactions (troughs) they are slightly farther apart. Our ears are so sensitive that they can still hear sounds where this pushing and pulling of the air molecules amounts to only about a billionth of an inch!

The distance between two neighboring compressions (or two neighboring rarefactions) is called the wave length, while the number of waves that come out of the source each second is called the frequency of the waves. What a musician calls the "pitch" of a tone is directly associated with the frequency. A low note, such as one produced by striking a key near the left-hand side of the piano keyboard, is one of low frequency. A high, screechy note has a high frequency of vibration. The wave length multiplied by the frequency is always equal to the speed of the waves.

The human ear happens to be able to detect sound waves whose frequencies range from about 20 up to about 20,000 vibrations per second. Any air vibration that falls outside this range makes no impression at all on the average person's ear, but some animals can hear much higher frequencies. Bats, for instance, produce sounds of more than 50,000 vibrations per second to guide them in flight (see SCIENCE WORLD, Nov. 25, 1958, p. 11).

For technical purposes, the range of frequencies from 15,000 upward is called the ultrasonic region. The two parts of the name come from Latin roots, *ultra* meaning "beyond" and *sonic* meaning "relating to sound." (Do not confuse this word with *super*sonic — a term applied to aircraft and missiles capable of going faster than the speed of sound.)

Ultrasonic waves having frequencies as high as ten billion have been

— Photo from Westinghouse Corporation

Two thin strips of aluminum are being welded together by silent sound in this experimental device. Strips are passed between two vibrating metal wheels. Ultrasonic waves knead and intermix the crystals of the aluminum, binding the strips together.

produced experimentally, but the kind most used for a variety of practical jobs have frequencies of from about 20,000 to 1,000,000. Whereas the waves of ordinary audible sounds usually can be measured in feet, those of the ultrasonic region are likely to be measured in hundredths of an inch, and this fact makes a great difference in what they can do.

Vibrating strings, organ pipes, or loud-speakers are useless for the production of ultrasounds. These instruments are simply too slow. In order to generate high-frequency sound waves that are strong enough for practical purposes, special sources must be built. One such generator, or transducer, for producing ultrasound is made from a thin slice of a quartz crystal. The wafer of quartz is placed between two metal plates that are connected to an electrical oscillator circuit in which the current can be made to surge back and forth at high frequency. When this happens, the crystal alternately swells up and shrinks, perhaps by less than a thousandth of an inch. It does this in time with the electrical surges in the circuit, and acts as a source of ultrasonic waves in the surrounding air or other material in which the crystal is placed.

Ordinary sound waves spread out in all directions from their source, but ultrasonic waves, being so much shorter, can be made to travel in a straight beam. They can be reflected from mirrors and curved reflectors, like a beam from a searchlight. This makes it possible to concentrate large amounts of sound energy in a small space. Another important circumstance is that the energy carried by waves is proportional to the square of their frequency. This means that, with all other conditions the same, ultrasound of 100,000 vibrations has 10,000 times the energy concentration of audible sound of frequency 1,000.

Scientists began exploring the field of ultrasonic waves back in the 1930's. The gifted experimenter, Professor Robert W. Wood of Johns Hopkins University, attached a thin "cat's whisker" to a vibrating quartz crystal. A drop of oil placed on the fiber was instantly changed to a mist when the crystal was vibrated. Touching the fiber gave Professor Wood's finger a painful burn. Snails and small fish could be killed by putting the vibrating crystal in an aquarium. These experiments attracted much attention, but they were mere curiosities. The real uses of ultrasonics were to come later.

Today, ultrasonic waves find some of their most significant applications in the laboratory and in the factory. If an ultrasonic transducer is put into a vessel containing a liquid, the waves move the liquid back and forth hundreds of thousands of times a second. This means a violent shaking-up of the liquid itself and of any small particles that may be spread through it. Ultrasound is now used in this way in many industrial processes where the problem is to make things dissolve or mix quickly with liquids. The makers of photographic film find that mixing their chemicals by the use of sound waves results in a more sensitive film. Paint manufacturers use ultrasound to do a better job of mixing and blending paints.

A new portable washing machine now on the market is simply an ultrasonic transducer that can be dipped into a basin of soapy water containing the soiled clothes. The sound waves drive the soap solution back and forth through the pores of the fabric so fast that everything

is scrubbed clean in a short time. And there is said to be much less wear on the clothes because the large-scale surface-rubbing action of the usual washing process is absent.

Even newer is a dishwasher using high-frequency sound waves. Even stubborn, clinging dried egg yolk and gravies yield to the frenzied wearing action of the sound vibrations.

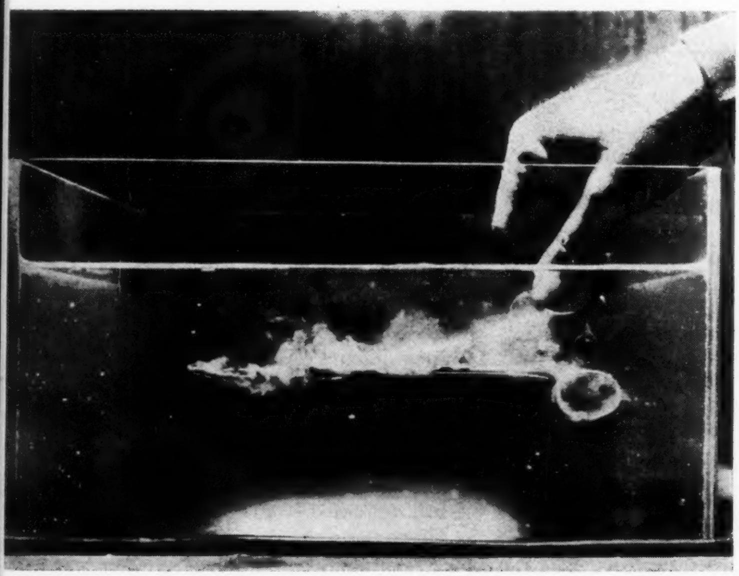
An optical company is now using ultrasonic methods for cleaning lenses. One machine can handle a thousand lenses an hour, taking the place of two dozen people using older methods. The Atomic Energy Commission finds that radioactive laboratory parts can be decontaminated in one minute by ultrasonic scrubbing. Formerly, the process took a quarter of an hour.

In liquids, the action of ultrasonic waves can move the particles so fast that tiny holes form all through the liquid. This is a process that physicists call *cavitation*. Almost as soon as these cavities form, the pressure of the liquid makes them collapse again. The very sudden collapse results in a powerful pounding action. (On a mild scale, this is what is happening when a teakettle of water begins to "sing," shortly before boiling. The singing sound is made by the collapse of a host of vapor bubbles in the water.)

The cavitating action of ultrasound makes it useful in doing a double job in the dairy industry. It can be used to homogenize milk and, at the same time, sterilize it. Milk is a suspension of myriad little fat globules in a watery fluid. In order to make the milk more digestible, these globules are usually broken up by forcing the whole milk through very small openings under pressure. The smaller drops have a greater total surface and can therefore be attacked more effectively by the digestive juices. Besides, they have less tendency to separate from the liquid. In the new method, the sound waves not only break up the fat globules but serve also to destroy bacteria, literally by pounding their cell walls to pieces.

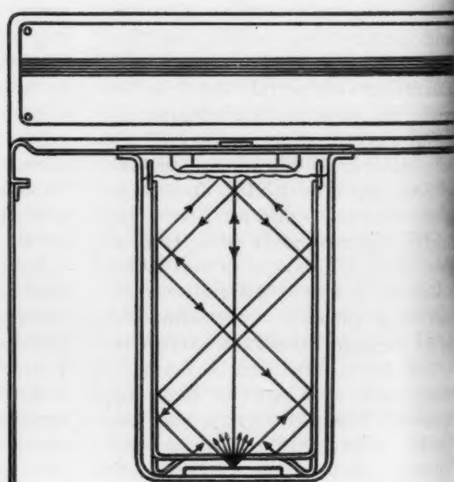
A slightly different use of ultrasound makes it valuable in a variety of cutting and drilling operations in the machine shop. In a widely used commercial apparatus for cutting and drilling, the source of ultrasonic vibrations is not a crystal but a stack of nickel disks surrounded by a coil. High-frequency alternating current sent through this coil will magnetize the

— Photo and drawing from Acoustica Associates, Inc



FROTHING SCISSORS are being cleaned by inaudible sound waves in this transparent model of ultrasonic washer. Sound waves have a 'cold-boiling' effect on water.

HOW SILENT SOUND WAVES radiate through water is shown in this cross-section diagram of ultrasonic washing machine for surgical instruments.



nickel, first in one direction and then in the other. Since this metal has the property of shrinking a little when it becomes magnetized, the result is a high-speed vibration of the stack of disks. A metal point attached to the stack moves about four ten-thousandths of an inch when driven at 27,000 vibrations per second.

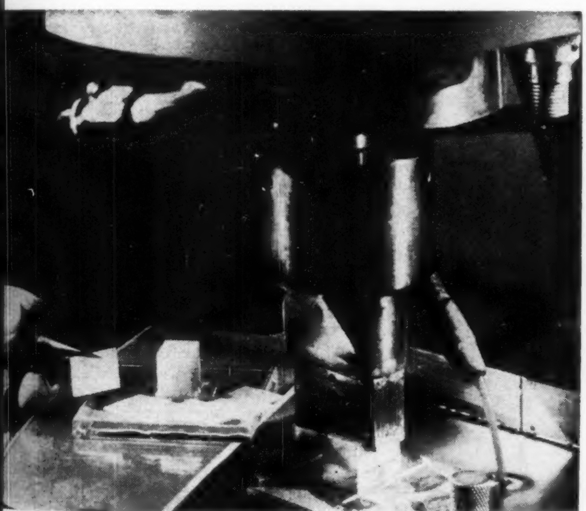
Suppose it is desired to cut or engrave the surface of a piece of glass or metal at a certain place. A paste containing an abrasive material such as Carborundum is allowed to flow over the surface. Then the vibrating tip of the tool is made to touch the paste. Instantly, powerful ultrasonic waves are set up in the paste. They drive the abrasive particles back and forth, scouring the surface and wearing it away. The tool itself never touches the work and there is very little heat produced. In certain manufacturing operations involving engraving, drilling, or cutting there is nothing better; and costs in some of these operations have been cut as much as 80 per cent by using ultrasonic methods.

The thin quartz wafers used in the ultrasonic generators described previously can be cut by this method, using a slightly different form of tool. A large number of such crystal slices, each about twelve one-thousandths of an inch thick, can be cut at one time.

Ultrasonics, teamed up with electronic devices for measuring very short time intervals, permits engineers to locate hidden cracks in metal machine parts. If a beam of ultrasonic waves is sent down into a metal casting, some of the waves will be reflected from the back of the piece. Any flaw or crack inside the piece will reflect the waves, too. By checking whether the down-and-back travel time corresponds to the full thickness of the piece or to a smaller distance, the machine not only determines if there is a hidden flaw in the metal but shows about how far below the surface it lies. The sound-wave method replaces the much more troublesome and dangerous X-ray inspections.

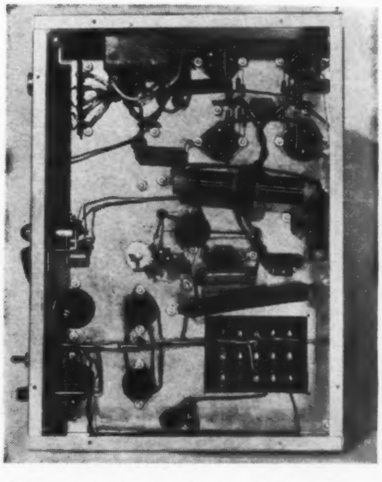
Additional uses of ultrasound are being developed all the time. Still in the experimental stage are methods of welding metals by literally knocking them together with sound waves. Over limited spaces, fogs, mists, and dust can be precipitated from air by similar methods. And even in the field of medicine, research workers are exploring the possibility of producing warmth deep inside the body by application of high-frequency sound waves.

— Photo from Raytheon Mfg. Co.



ASONIC GRINDER slices quartz into crystals for use in electronic its. Cutting tool vibrates rapidly up and down, while liquid ive flows between it and quartz. Ultrasonic waves drive tiny ive particles against quartz with such force that it's easily cut.

— Photo from Hermes-Sonic Co



INNER WORKINGS of an ultrasonic machine used to clean jewels, watch parts.

Science in the news

Desalting plant to help ease water shortage

Some of us may soon be drinking ocean water. For the U. S. is preparing to build the nation's first large-scale plant for removing salt from sea water. In all, five plants will be built. Their purpose: to head off what could become a critical fresh-water shortage in the U.S. Available fresh water is barely enough to meet current needs.

The first plant will desalt one million gallons of water a day. Its basic plan is similar to previous desalting schemes. Water will be boiled and turned into steam, leaving its impurities behind. The steam will then be condensed into pure water.

But the water will cost only one-seventh that of previous desalting operations. Two new features will slash costs. One is a system of long tubes to improve the evaporation process. The other is a new way of keeping salt scale from gumming up pipes. Salt crystals will be used as "bait" to lure scale out of the pipes.

The first plant will probably be built in southern California. Fresh-water shortages are especially acute there.

Ghostly atomic particle is tracked down

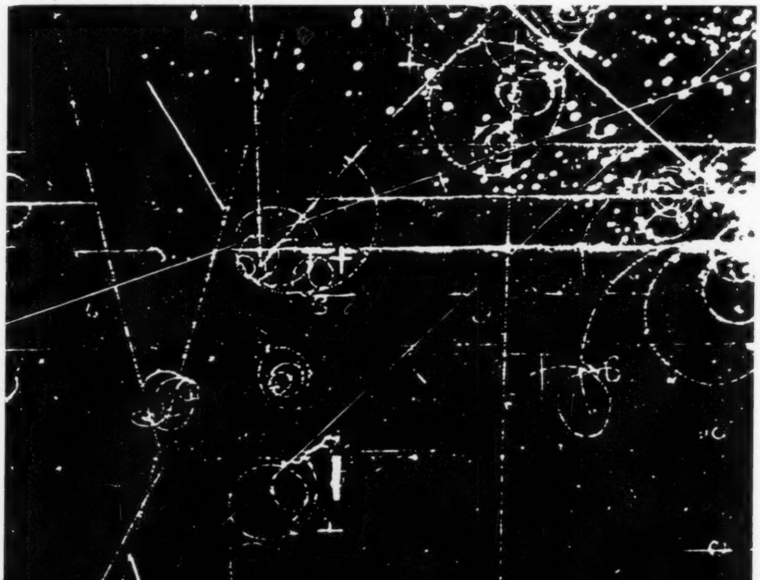
A new subatomic particle has been detected by physicists at the University of California. It is known as the Xi zero particle. It is the last particle of ordinary matter that scientists expect to find inside the atom.

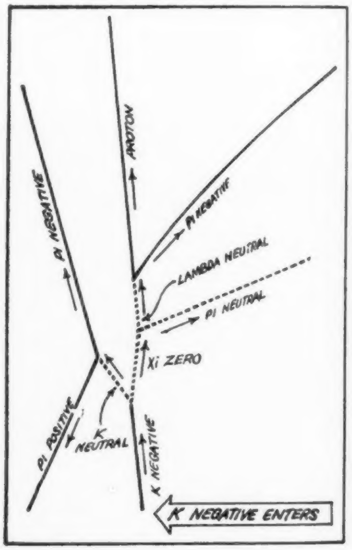
These particles can't be seen. But if they are electrically charged particles, they leave visible tracks under certain conditions. The Xi particle has no charge, so it makes no tracks. But the California physicists detected its presence by the reactions of other particles to it. Here's how they did it:

A beam of particles from a giant atom-smashing machine, the Bevatron, was passed through a liquid hydrogen bubble chamber. Debris from colliding particles left visible tracks. These were photographed. The behavior of tracks in one photograph (*below*) showed that they were affected by a ghostly subatomic particle. This proved Xi zero's existence. But 70,000 photographs had to be taken before the proof was found.

The existence of Xi zero had been previously predicted. Physicists estimate that the newly discovered particle has a mass 40 times as great as a proton and a lifetime of about one ten-billionth of a second. It is one of thirty fundamental particles known to man. Four of them are stable: photons, electrons, protons, and neutrinos. The others are unstable — they exist fleetingly for a few millionths of a second or less. (The only exception is the neutron, which lasts about 17 minutes.) When relationships among these particles are worked out, physicists hope to emerge with a new fundamental understanding of the nature of matter.

Courtesy Lawrence Radiation Laboratory, U. of Calif.





New subatomic particle called Xi zero was shown to exist by photograph (*left*), the only photo of 70,000 taken that revealed particle's presence. Xi has zero electric charge, leaves no tracks on photographic plates. But reaction of other particles to it in this photograph proved its existence. Diagram of photograph (*above*) gives clearer picture of how Xi zero affects other particles, changes their natures, paths.

A-blasts in space create band of radiation

Last September U.S. scientists created a thin band of radiation around the earth. The band was similar to the natural radiation bands discovered by U.S. satellites. It was produced by three small atomic explosions set off more than 300 miles above the earth. The blasts were kept secret until news of them leaked out last month.

The nuclear charges were carried into space by rockets launched from a ship. Exploding 300 miles up, they created a great "flash" of radiation. Fast-moving radioactive particles traveled along the earth's magnetic lines of force. These lines run north and south in arcs extending into space. They probably follow the pattern assumed by iron filings around a bar magnet.

In less than an hour the particles had surrounded the earth in a radiation band. The extent of the radiation was reported by the Explorer IV satellite, as it wove in and out of the band, and by rockets. The radiation produced auroras—great curtains of light—at two points: near Antarctica, where the blasts occurred, and some 8,000 miles north over the Atlantic Ocean.

The explosions were conducted under the code name of Project Argus. Some scientists describe the project as the greatest scientific experiment of all time. When they have studied all the data, scientists expect to know much more about the earth's magnetic field and the behavior of radiation in space. They speculate that man-made radiation in space may have world-wide effects similar to those of magnetic storms. These storms are believed to cause auroras and radio blackouts (see *SW* April 21).

The blasts also had military significance. They may help answer questions such as these: (1) Could an enemy use such blasts to disrupt our radar and radio communications so that we might have no warning of a missile attack? (2) Could man-made radiation in space be used as a kind of "death ray" to destroy enemy missiles?

Clay tablets reveal life and times of ancients

Handwriting on several hundred clay tablets has revealed a great deal about the life and times of an ancient people. An archeologist who deciphered the writing says it discloses that a highly organized society existed about 5,000 years ago in what is now Iraq.

Written by scribes around 3,000 B.C., the tablets describe ancient communities on the northern shores of the Persian Gulf. Community rule stemmed from the temple. Citizens borrowed from their temple and paid taxes to it. A court system with judges handed down decisions based on statements by witnesses. Some decisions involved disputes between husbands and wives and arguments over property. Trades and crafts were highly developed. Some of the 393 tablets refer to weavers, silversmiths, and leather workers. Wages were fixed and usually paid in the form of food or other goods.

The writing on the clay tablets was done by the Sumerian and Akkadian peoples. The Sumerians, whose origin is not known, kept to themselves. When the Akkadians moved into the Sumerian area, they stimulated trade among the self-contained communities and spread the Sumerian form of writing to other countries.

Virus that harms plants is helpful to animal

A virus that is naturally beneficial to an animal has been found. Its discovery may open a whole new field of virus research.

The tiny virus (a million, side by side, cover no more than an inch) attacks aster plants. It gives them "yellows," a disease that shrivels them and prevents them from flowering. But when an insect called the corn leaf hopper takes in the virus, it can eat food that would normally poison it.

Ordinarily, the corn leaf hopper can eat only corn leaves. When it is infected with the virus, however, it can eat aster leaves without ill effect. Does the virus directly affect the corn leaf hopper? Or does it change aster plants in some way that enables the insect to eat them? A scientist at The Rockefeller Institute in New York City, where the virus was discovered, says we simply don't have the answer to this yet.

The virus is of no use to the aster leaf hopper, another insect. When this insect takes in the virus while sucking fluid from aster plants, the virus multiplies and causes a mild inflammation. But that's all. The virus doesn't similarly inflame the corn leaf hopper, says the Rockefeller scientist, because it probably multiplies more slowly in that insect.

Many viruses are helpful to plants. But until now none has been discovered that in its natural state aids animals or people. When killed or weakened, however, disease viruses can aid humans and animals. They are then used as vaccines for immunization.

News in brief

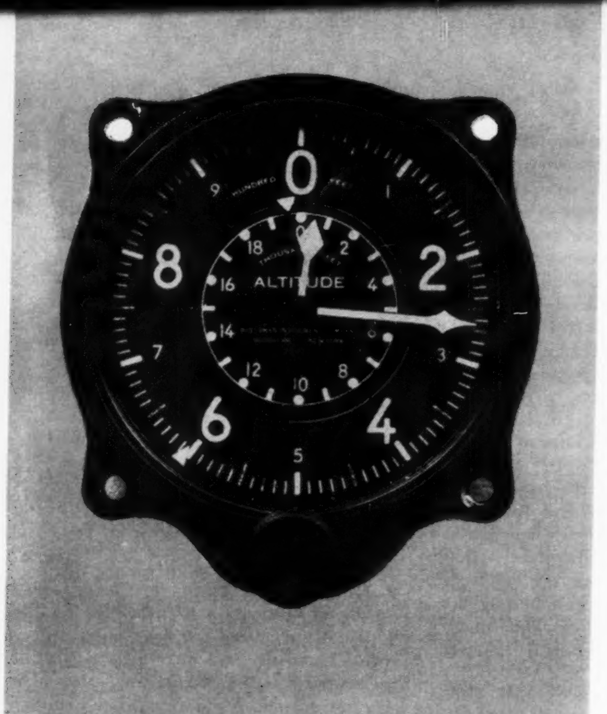
● Nestled under the right wing of an eight-jet B-52, the X-15 rocket plane made its flight debut. To test the stability of the X-15 in flight, the coupled planes circled for more than an hour at an altitude of 38,000 feet. The flight was the first in a long series of tests that will be made to determine the plane's capacity to reach speeds of 3,500 miles an hour at altitudes upward of 100 miles. Designed to be our first manned space vehicle, the X-15 is a joint project of the National Aeronautics and Space Administration, the Air Force, and the Navy.

● The antarctic's Emperor penguins are dying out, says a French explorer. These strange birds produce only one egg per mating, and only a fourth of their total number of offspring survive Antarctica's savage winters. The penguins reverse the normal cycle of birds in the polar land: when other birds leave in autumn, the penguins arrive to bear and raise their young. Each year fewer Emperors leave and fewer return, says the explorer.

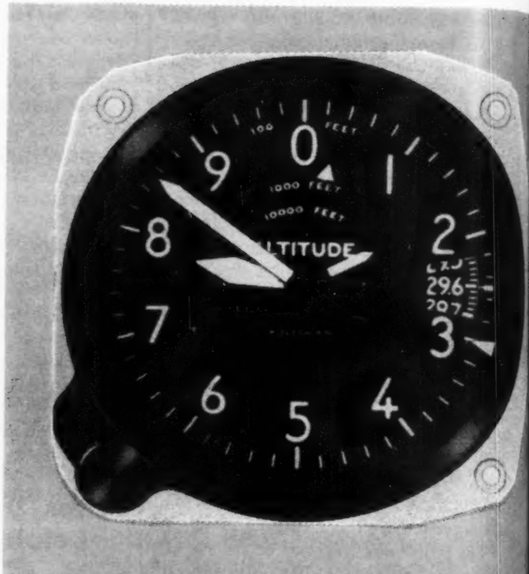
● Before its battery power was exhausted, Pioneer IV, our sun-orbiting asteroid, set a record. Its last message to earth was radioed from a distance of more than 410,000 miles. Russia's Mechta, also orbiting the sun, sent back its last message from 370,000 miles in space. Mechta's batteries fell silent after 62 hours of flight; Pioneer's, after 83 hours.

● A new satellite-launcher, dubbed the "poor man's rocket," will be used next year. Known officially as Scout, it is a four-stage vehicle. Its nickname stems from the fact that its solid-propellant rocket engines will make it relatively cheap to build. They will also make it more reliable and simpler to fire than the usual liquid-propellant rockets. Scout will be able to hoist a 150-pound satellite into a 300-mile-high orbit, according to the National Aeronautics and Space Administration. Besides launching satellites, it will be used in space experiments that must be repeated several times.

● A sneezing cat may have a head cold, but a human being can't catch it, reports a Cornell University scientist. A feline virus called pneumonitis causes the animal to sneeze, lose its appetite, and drool excessively. Pneumonitis is contagious among cats, the scientist says, but can't be transmitted to humans.



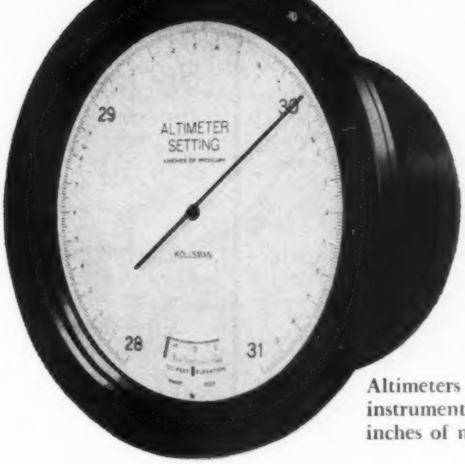
Early altimeter used by James H. Doolittle for blind-flying tests. Reading: 265 feet.



Standard three-needle altimeter found in most aircraft today. Reading: 17,850 feet.

Controversial drum altimeter replaces two needles with drum. Reading: 17,080 feet.

— Illustrations from Kollsman Instrument Corp.



Altimeters are set by this instrument. Reading: 30 inches of mercury absolute

Spotlight on the altimeter

Science in the news

■ The altimeter -- one of the most elementary yet vitally important instruments in flying — is much in the news these days. Reason: the tragic crash of an Electra prop-jet airliner, with a loss of sixty-five lives. The plane fell into New York's East River on February 3, while approaching La Guardia Airport for a night landing during foul weather.

The full cause of the crash was not immediately established. But the Federal Aviation Agency ordered the new type of altimeters used on Electras replaced. It later became known that the plane's altimeters were reading about 500 feet at the time of the crash. These developments show that the simple, usually reliable altimeter is as important in this jet age as ever.

Altimeters have been used in airplanes since the earliest days of aviation. But the pioneer fliers learned that "flying by the seat of their pants" was often safer than depending on the relatively crude and inaccurate instruments mounted in their cockpits. It was not until 1928 that the altimeter came of age. In that year Paul Kollsman, founder of the Kollsman Instrument Corporation, invented a revolutionary instrument that was accurate and dependable. It was called the Sensitive Altimeter. In an historic flight, it proved itself — and set the stage for modern instrument flying.

The date was September 24, 1929. Lieutenant James Doolittle was making his first claim to fame. He was trying to prove that weather — then, as now, man's greatest enemy in the air — could be licked. Taking off from Mitchell Field on Long Island, Doolittle, with no reference except his instruments, flew a fifteen-mile course and landed safely. It was the first "blind-flying" mission of importance, and the new altimeter came through faultlessly. In modernized form, this same Sensitive Altimeter is the basic instrument now used by thousands of aircraft all over the world.

The altimeter is essentially an aneroid barometer — a barometer that uses no liquid. It senses air pressure changes at varying altitudes and converts these changes into accurate measurements of height. Air pressure, of course, drops as altitude increases. The reason: the higher you go, the less dense the air becomes.

Inside the altimeter's small (3¼" x 3⅞") housing is a chamber from which the air has been removed. Part of the chamber consists of a sensitive diaphragm. As an aircraft climbs, the diaphragm expands under the lower outside pressure. This triggers a series of gears that move dial pointers to the proper altitude readings. The altimeter normally registers zero feet at standard sea-level pressure (29.92 inches of mercury) at 59° F. A small adjustment knob allows the pilot to compensate for constantly changing pressures.

Weather changes — thunderstorms, air spilling over mountain crests, and sudden updrafts and downdrafts — also affect altimeters.

The new altimeter used in the Electra emerged from Air Force studies aimed at finding an instrument that would be more accurate and easier to read in high-speed jets. Pilots are still divided in their opinion of the new altimeter. It registers thousands of feet on a drum, hundreds of feet with a needle. Ordinary altimeters use three needles. Many airmen — perhaps used to the familiar older model — claim the drum model is harder to read; others swear it is far easier.

According to reports, the FAA ban on the drum-type altimeter was prompted by a tendency of the instrument's needle to stick. Boeing, in its 707's, put in a vibrator that constantly jiggles the altimeter, preventing it from ever sticking. Sticking is a problem in many old as well as new altimeters.

Before taking off, a pilot always sets his altimeter at the field's barometric reading, which is recorded on the control tower master instrument. He resets it again for the reading at his destination before landing. Varying altitudes and weather conditions at airports cause each to have a different barometric reading.

Developed in the Ford Tri-Motor era, the altimeter has safely lived into the jet age. Standard Air Force altimeters now register up to 80,000 feet. But this is one case where the sky is *not* the limit. In the airless void of outer space, the old reliable altimeter will find itself out of work.

— Jules Bergman

Young scientists

YOU ASKED FOR IT

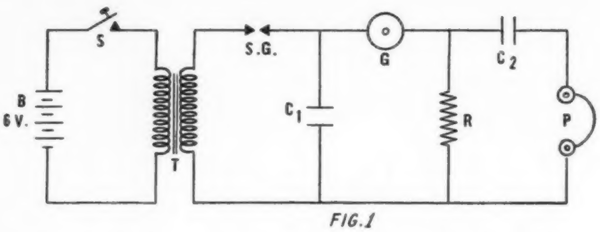


FIG.1

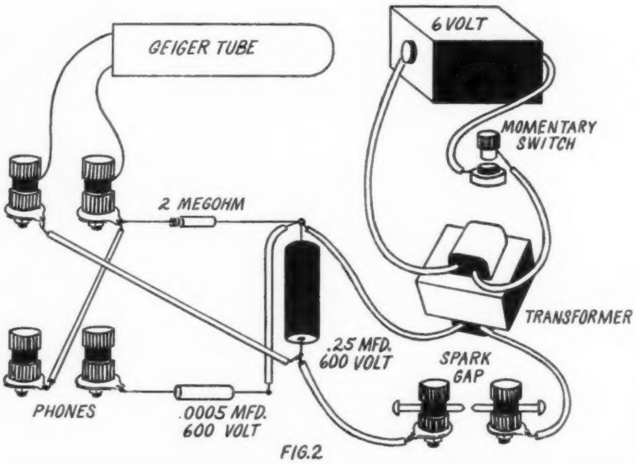


FIG.2

■ SCIENCE WORLD receives a steady stream of letters asking for help with or information on science projects. The number of requests is so great that it is, unfortunately, impossible to fill any of them. We can offer no help with projects beyond the suggestions given on these pages. However, certain subjects turn up so often in these letters that they appear to be of very wide general interest. For this reason, we have chosen two of the most common subjects for discussion here.

A homemade Geiger counter

A simple but very serviceable Geiger counter can be made by anyone who can handle a soldering iron. Its principle of operation can be understood by anyone who has a smattering of knowledge concerning electricity and electrical circuits.

The conventional diagram of the circuit for the Geiger counter is given in Fig. 1. For those who may have difficulty in reading this type of diagram, a pictorial one is shown in Fig. 2.

Let's start by examining the theory of operation of this Geiger counter. The heart of the counter is the Geiger tube. This tube consists of little more than two electrodes that have a D.C. potential just below the point at which a spark passes between them. Tubes are built for different firing voltages. Any 300- to 700-volt tube such as the 30-G made by Electronics Products Co., Inc. (Mount Vernon, N.Y.) will be satisfactory for this counter.

As a ray or particle enters the Geiger tube, it ionizes the gas in the tube and causes a momentary spark. This spark does not continue, because the flow of current through the resistance (R), in series with the tube, (Fig. 1) causes a drop in the voltage across the tube. The spark is thus "quenched," and the tube is ready for the next ionizing radiation. The voltage drop across R at each pulse operates the headphones (P) through the small capacitor, (C_2). For each ray or particle entering the tube, a click will be heard in the earphones.

The next step is to supply the Geiger tube with the necessary high voltage. This is done in the circuit containing the battery (B), the transformer (T), the momentary contact switch (S), the spark gap (S.G.), and the storage condenser (C_1).

Here is how the high voltage is made. Each time the momentary contact switch (S) closes and opens, current surges into the primary of the step-up transformer (T); a high voltage is induced in the secondary. The voltage is sufficiently high to jump the gap (S.G.), and charge up the condenser (C_1). Repeated pressing and releasing of the momentary contact switch can build up the charge in C_1 until it is sufficient to operate the Geiger tube. In other words, the source of power for the tube is the stored charge in the condenser (C_1).

Just a word concerning the parts. The transformer (T) is an output transformer from a discarded radio receiver. This transformer is the one that is generally found mounted on the speaker of the set. Carefully clip the two leads that go to the voice coil of the speaker. Then clip the primary coil leads and remove the transformer. In this application, the transformer is used in reverse. Current from the battery is sent into the low resistance winding which was originally connected to the voice coil of the speaker. The secondary, which has many turns of wire and relatively high resistance, is the winding originally connected to the plate circuit of the output tube.

The spark gap is made by inserting small machine screws, previously sharpened to a point, into binding posts. The binding posts may be of the screw type or they may be Fahnstock clips. The gap distance is not critical, but should be of the order of 2 mm.

The storage condenser is a 0.25 mfd.,

600-volt condenser. Once charged, this condenser may operate the counter for several minutes, thus permitting the battery to be disconnected and the counter to be carried about. If you find that with a 700-volt Geiger tube it takes too long to charge the condenser, substitute a 0.1 mfd., 1000-volt condenser for C_1.

All parts can be mounted on a 4" x 6" wooden board or, if you wish, in a plastic box.

To operate the Geiger counter, the momentary contact switch should be pressed and released sharply about 15 or 20 times. This charges the condenser sufficiently to operate the Geiger tube for several minutes. Pressing and releasing at 15-second intervals should maintain the voltage.

If at first the counter fails to operate, reverse the battery connections, since, depending on the direction of winding of the transformer, the polarity on the Geiger tube may be reversed. The counter will give a background of 20 to 25 counts per minute and will respond to relatively low levels of radiation. For test purposes use a watch with a luminous dial as a source of radiation.

More about crystals

The November 11, 1958 issue of Science World described various methods for growing crystals. Here is a supplement, telling how to grow crystals illustrating the seven crystal systems. It describes a simple over-all system for growing crystals and indicates the quantity of material that will dissolve in a convenient volume of water (see table at right).

To obtain good crystals of any of the chemicals listed in the table, measure out 100 cc. of distilled water into a beaker. Add to it the suggested quantity of the chemical you've chosen. Stir the mixture well, and heat until the solid is completely dissolved. Filter the solution (even though it appears clear) into a perfectly clean, warmed, flat crystallizing dish. The size of the dish should be so chosen that the liquid fills it to a depth of about 1 inch. Cover the dish lightly with paper or cheesecloth. Allow it to stand overnight in a draft-free cupboard.

As soon as possible the next morning, remove any crystals that have formed. Dry them on filter paper, taking care not to injure any of the faces. Then filter the solution into a warm crystallizing dish. Select one or two of the most perfectly formed crystals (which may be quite small), and replace them in the clear liquid after it has cooled. During the course of the next few days, turn the growing crystals so that a succession of different faces are in contact with the bottom of the dish.

To remove solids from the solution, add a few drops of warm concentrated solution to the main bulk after removing the crystals. Then, when the solution is cool, replace the crystals. This process should be repeated from time to time as necessary.

Note: it is absolutely essential during the growing of the crystals to prevent temperature fluctuation, as far as possible, and to exclude dust.

If you would like to exhibit your crystals, use the method shown in Fig. 3. Get a vial of suitable size. Insert four pins into its cork stopper so that their heads are at the same height. You may want to cover the heads with a small wad of absorbent cotton. Place the crystals on the prepared support, and then fit the tube onto the cork.

An interesting variation in crystal growth can be illustrated by employing the principle of isomorphism (*iso:* same, *morphos:* shape). If a crystal of copper sulphate is placed in a saturated solution of potassium dichromate, the potassium dichromate will deposit around the copper-sulphate crystal, because both belong to the same crystal system. If, however, a crystal of potassium alum is placed in the solution of potassium dichromate, no deposition occurs, since the two materials do not form crystals in the same system.

This principle, incidentally, was used in early experiments in the seeding of clouds. Silver iodide forms crystals in the hexagonal system. So does water — all snow crystals have six points. Thus, silver iodide can be used as a nucleus around which water in the form of ice will deposit. Once started, a delicately balanced situation can be tipped, and rain will result.

— Theodore Benjamin

The weights below refer to the amount of solid, whose formula is given, which might conveniently be dissolved in 100 cc. of water when making crystals according to the method described above.

Isometric system
- Potash alum, $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ [16 gm.]
- Lead nitrate, $Pb(NO_3)_2$ [56 gm.]
- Chrome alum, $K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24H_2O$ [25 gm.]

Tetragonal system
- Potassium dihydrogen phosphate, KH_2PO_4 [45 gm.]

Orthorhombic system
- Potassium chromate, K_2CrO_4 [65 gm.]
- Magnesium sulphate, $MgSO_4 \cdot 7H_2O$ [130 gm.]

Monoclinic system
- Potassium ferricyanide, $K_3Fe(CN)_6$ [42 gm.]
- Ferrous ammonium sulphate, $Fe(SO_4) \cdot (NH_4)_2 SO_4 \cdot 6H_2O$ [38 gm.]
- Nickel ammonium sulphate, $NiSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$ [12 gm.]

Triclinic system
- Copper sulphate, $CuSO_4 \cdot 5H_2O$ [43 gm.]
- Potassium dichromate, $K_2Cr_2O_7$ [12 gm.]

Rhombohedral system
- Sodium nitrate, Na_2NO_3 [90 gm.]

Hexagonal system
- Ferrous chloride, $FeCL_2$ [70 gm.]

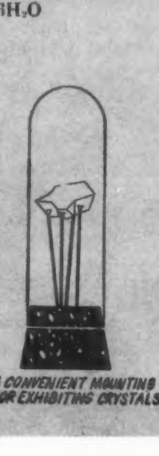


FIG. 3. A CONVENIENT MOUNTING FOR EXHIBITING CRYSTALS

Marguerite Harris of North Chicago, Illinois, writes:

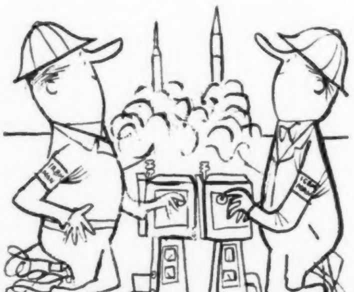
Where did each of the planets get its name?

All planets (except the earth) were named after ancient mythological gods. Five planets, known in early times, were so named by the ancients. For the sake of consistency, the three planets discovered later were similarly named. The planets and their namesakes: *Mercury,* named after the messenger to the gods, because of its rapid movement; *Venus,* after the goddess of love, because of its brightness; *Mars,* after the god of war, because it appeared reddish, the color of blood; *Jupiter,* after the king of the gods, because it was the giant of the planets; *Saturn,* after the god of time, because it seemed to move more slowly than the rest; *Uranus* (discovered in 1781), after the god of the sky, perhaps because it was then the remotest of the planets; *Neptune* (1846), after the god of the sea, an appropriate name in view of the planet's greenish appearance; *Pluto* (officially recognized as a planet in 1930), after the god of darkness, a fitting name for a planet that is eternally dark because of its great distance from the sun.

Luis D. Vega of Mayaguez, Puerto Rico, writes:

What do IRBM and ICBM mean? How do these missiles differ?

IRBM means Intermediate Range Ballistic Missile; ICBM, Intercontinental Ballistic Missile. They differ in their range — the distance they travel. An IRBM is designed to hit targets about 1,500 miles away. An ICBM has a range of around 6,000 miles, enough to take it from one continent to another. Both missiles are called *ballistic* because they are guided only during their brief period of propulsion. After that, they coast to the target, following the same kind of path as a shell or other projectile. They are meant to hit stationary targets, such as cities. They are also used to launch space vehicles. An Army IRBM, Jupiter, was the first stage of the rocket that launched the Pioneer IV moon probe.

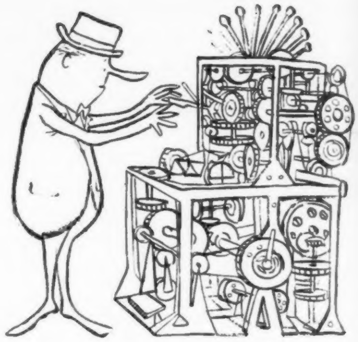


Charles Wilson of Albany, New York writes:

Why are the oceans salty?

Oceans get their salts from the land. Rivers pick up salts that have been washed out of the land. When the rivers empty into the oceans, they carry the salts with them. Many geologists think that a large proportion of ocean salts originally came from the water in the earth's interior, which was brought to the surface by volcanoes.

Over the centuries, oceans have dissolved enormous amounts of salts from lands they have covered. The average salinity (saltiness) of the sea is estimated at 35 parts of salts for every 1,000 parts of sea water. Climate also influences the sea's salinity. In the lagoons of southern Texas, for example, where rainfall is scant and evaporation heavy, salinity is very high. The Arctic Ocean, which receives much river water and evaporates only slightly, has a very low salt content.



Malcolm Metcalfe of Trail, British Columbia, writes:

Could perpetual motion be achieved?

Not by man. A true perpetual-motion machine would run indefinitely *without* an outside source of power. But machines built by man are necessarily handicapped by friction. A machine must eventually use up all its power overcoming this friction. With its power gone, the machine stops. Only with an outside source of power can it keep running. The earth, however, can be considered as a perpetual-motion machine. It has no axle to slow its rotation, and there is no air in outer space to retard its motion. Friction doesn't exist between the earth and its atmosphere, because both rotate together.

Mark Popma of Oswego, Oregon, writes:

What is the sound barrier?

The sound barrier is a pile-up of turbulent air that until fairly recently prevented aircraft from flying faster than the speed of sound. (The speed of sound, which varies with air density and temperature, is in the general neighborhood of 700 miles an hour.) As an airplane flies through the air, it squeezes together (compresses) the air in front of it. Pressure waves form that travel ahead of the aircraft. These seem to prepare the air ahead so that it slides smoothly over the plane's surfaces. The slower the plane's speed, the farther in front of it are the pressure waves. When the plane approaches the speed of sound, however, it overtakes the waves and flies into them. Before aircraft were designed to fly at supersonic speeds, they were often shaken to pieces when they flew into pressure waves. Now aircraft can fly at two or three times the speed of sound in perfect safety.

Questions from readers will be answered here, as space permits. Send to: Question Box, Science World, 575 Madison Avenue, New York 22, N.Y.

The cars are safer... the roads are safer...

THE REST IS UP TO YOU !

Bet you enjoy getting behind the wheel of the family car and going places, like taking your crowd to the ball game. Did you ever stop to consider what a big responsibility that is? You're in complete charge of the car and your friends' very lives depend on how you handle it.

Other people are helping you to drive safely. The automotive industry has come up with power brakes and power steering, bigger windshields and windows for better visibility, better roadability and improved lighting. Highway and traffic experts have contributed underpasses, interchanges, divided highways, and easy-to-read, day-night traffic signs. All of these improvements and more are making it easy for you to be a safe driver, but they mean little unless you cooperate.

Safe driving is primarily *your* business, and it's profitable, too! When your family knows that you're careful with the car, you get to drive it more often!

GENERAL MOTORS A CAR IS A BIG RESPONSIBILITY—SO HANDLE WITH CARE!

Stranger than fiction

By Murray Morgan

They hunt the smallest game

In the jungles of the Amazon, two American doctors hunt the smallest and most dangerous of game — viruses

PART I ■ Belém, a spacious, moldering port near the mouth of the Amazon, has long been the jumping-off place for big-game hunters. In recent years it has served, too, as headquarters for a middle-aged American couple who hunt the smallest living game, and perhaps the most deadly — viruses.

The virus-hunters of the Amazon are the Drs. Ottis and Calista Causey. The male Dr. Causey is a short, plump man with soft brown hair and gentle blue eyes. Horn-rimmed glasses dangle from a plastic band around his neck. His voice, though rather high, is soft, slurred with the accent of his native South Carolina. The female Dr. Causey — Calista — who was born in Florida and educated in Oregon, is a small, wrenlike woman with light brown hair and eyebrows arched into a look of permanent pleased surprise. The Causeys look as if they ought to be running a soda fountain in a small town instead of pursuing invisible killers through some of the world's thickest jungle and conducting dangerous laboratory experiments with improvised equipment in a quaint old mansion.

The Drs. Causey do their virus-stalking on behalf of The Rockefeller Foundation's Biological and Medical Research Program, which has established a world-wide network of laboratories to study certain micro-organisms. This is an outgrowth of the yellow-fever-virus work on which the Foundation worked for a number of years and on which the Regional Office of the World Health Organization is now working. (See *SW*, Nov. 11, Nov. 25, Dec. 9, 1958.) There are Rockefeller virus-hunters in Johannesburg, California, Trinidad, and India, as well as on the Amazon. But Dr. Jordi Casals of the central laboratory in New York, whose assignment it is to identify the viruses sent in by the Foundation's far-flung trappers, says the Causeys have come up with more new strains and found more old ones in new places than all the other search parties combined.

Ottis Causey attributes this big bag of tiny killers chiefly to the abundance of virus in the forests of the Amazon. "We have found the loveliest diseases right in our back yard," he remarked one day as we tramped through a light rain along a jungle trail outside Belém. "Yellow fever, Venezuelan equine encephalomyelitis, Eastern equine encephalomyelitis, St. Louis equine encephalomyelitis, and lots of others that didn't have names when we found them but are now called for the places where they were discovered — Oriboca, Marituba, Apeu, and Guamá. Besides that, we have some sixty unknown viruses awaiting classification by the laboratory in New York, although of course there may be a great deal of duplication among them. It's a fine, unhealthy place.

"There is in the jungle a pool of disease which is carried in the blood of animals and birds, some of it capable of affecting human beings. It may be that the jungle will turn out to be the great reservoir of virus disease and that it overflows from here to other parts of the world. It may be that birds carry the viruses to far countries. It may be that some viruses that are now benign — which can multiply in man but at present do not affect him adversely — may change and become deadly to man. Viruses waiting for a disease, they're sometimes called. This is just a speculation, you understand. We don't know — but it's important that we find out, and the first step in finding out is to learn what viruses there are in the jungle."

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The killers that make the jungle so dangerous to man live in the blood streams of the forest animals. So the Drs. Causey go hunting with syringes. The viruses make their presence felt through fevers. Usually they last in the blood only a few days before either killing their host or succumbing to the attacks of the antibodies. Any report of an interesting fever along the Amazon is enough to start the Causeys loading medical kits and picnic baskets for a blood-collecting expedition.

They go virus-hunting by Chevy or Jeep or motor launch; by open-decked river steamers or dugouts; on horseback, in sleek new Constellations, or in fat, over-aged Catalina flying boats. Sometimes they walk.

Their longest trip was a flight to an area near the Bolivian border. They had reports of an outbreak of fever in a remote village. They flew for two days, then went up a river in a launch until the stream got too narrow and they transferred to bateaux. When it narrowed to a point where the bateaux were too big, they debated trying to continue in small pirogues. That argument was ended when the chief of the village they were to visit appeared on the scene. He reported that everyone was well again. But, he said, next time any people got sick he would be glad to order them to paddle down the river to meet the Causeys.

Most of the Causeys' expeditions are less elaborate. There are plenty of fever patients to bleed within a half-day's journey from Belém.

"What we anticipate particularly," Dr. Causey explained to me, "are circumstances in which a number of people who have not previously been exposed to the jungle and are therefore without antibodies against the viruses have to enter the forest and work there. They develop virus infections, and all we have to do is bleed them in the early days of the fever, then isolate the viruses in the laboratory. The results of sending people into the jungle are particularly good — from our point of view, of course — if they have to clear trees. That stirs up the insect vectors that transmit the diseases."

Shortly after the Causeys arrived in Belém to set up the Rockefeller laboratory in the fall of 1954, Dr. Causey heard that the Pirelli Rubber Company had purchased a swath of jungle not far from the town and was about to send men into the forest to open trails. The moment he learned of the project, Dr. Causey rushed off to see the plantation manager and told him that he wanted samples of the workers' blood before cutting started, to compare with samples he would take later.

"Too late," said the manager. "The trail-cutters are already at work."

"Then I must get samples before they get sick and develop antibodies."

"Too late. Some are sick already."

"How long have they been sick?"

"Three days."

"There's still time. I must bleed them immediately, before the virus dies out."

"Too late. It's after dark, and there's no road — just a trail through the mud for four or five kilometers."

"Let's go."

At the end of the jungle trail, in a small clearing deep in the forest, Dr. Causey found three feverish men bedded down in hammocks. By lamplight, he bled them. Within the next three weeks, six other forest workers came down with fever and were bled. When the laboratory reports came in from New York they showed what Dr. Causey had immediately suspected: yellow fever. The Yellow Fever Service gave shots to all workers in the forest and to inhabitants in the contiguous counties. The clearing operations in the forest caused the retreat of the Alouatta and Saimiri monkeys which had presumably served as the reservoir of the disease. Within a few months the yellow-fever outbreak — Brazil's last — was over, but the Pirelli plantation continues to yield an interesting and important crop of viruses. The Causeys have found on it the first case of Venezuelan equine encephalomyelitis to be isolated on the Amazon, and three previously unidentified viral agents.

During my stay in Belém I visited the plantation with the doctor. We did not have to walk along the trail Dr. Causey had first traversed by lamplight, for there is now a road through the jungle. The trees are neither very tall nor very large through the trunk, but the tangle of creepers and other undergrowth makes a solid wall on

Yours for the asking

Career data for astronomy-minded students is outlined in *A Career in Astronomy*. This brief American Astronomical Society brochure lists necessary high school and college courses; universities offering an undergraduate major in astronomy; career opportunities; reading list. Write to: Committee on Education in Astronomy, American Museum-Hayden Planetarium, 81st Street at Central Park West, New York 24, N.Y. Requests must include stamped, self-addressed envelope. (*Note: do not use coupon for this material.*)

The American Heart Association has available a two-color chart called *The Circulatory System*. The chart — which shows artery-capillary-vein sequence — can be inserted in loose-leaf notebooks. Request from your local Heart Association, or write to: American Heart Association, Inc., 44 East 23 Street, New York 10, N.Y. (*Do not use coupon to request chart.*)

The gyroscope — as it exists in nature and as it has been developed for scientific purposes — is discussed in a 34-page booklet by Sperry Gyroscope Company. *The Gyroscope through the Ages* chronicles early instrumentation and later refinements by tracing the development of the company's models and systems: gyro-compass, ship and airplane stabilizers, "blind" flight instruments, gyropilot, helicopter controls, etc. Check No. 471.

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each side of this road winding through the jungle.

Dr. Causey and I drove from the main plantation buildings to one of the camps where the workers lived. They slept in shelters that had no walls, just shake roofs supported by poles. The floors were dirt. The men slept in hammocks, which they suspended in tiers from the upright poles.

Two sick workers were lying in hammocks, dressed in work clothes — shorts and shirts. One had a temperature of 39.5 degrees centigrade, the equivalent of 103 degrees Fahrenheit. Dr. Causey questioned him about how long he had been sick (two days), how he felt (his head ached and he was dizzy and felt nausea when he stood), whether he had chills (no). Then he asked him to give blood.

Manuel watched without apparent interest while Dr. Causey drew blood from his right arm with a syringe, smeared a little on two plates for malarial tests, and put the vial containing the rest of the blood in a wooden box. He then gave Manuel a pill to help malaria, if that should be what he had, which Dr. Causey thought unlikely, and helped him back to bed.

The other boy, Paulo, had been bled three days earlier. He had taken a pill for malaria but was still showing fever. The doctor was quite sure that Paulo had something interesting.

Mrs. Causey was waiting at the door of the old mansion that served as the Rockefeller laboratory. She had on a white smock and was holding a test tube in her hand. The lab staff had gone home earlier.

"Any luck?" she asked her husband.

"I bled one." He opened his medical kit and handed her the vial dark with blood.

"Good case?"

"Uh-huh," he said, slipping into a white smock.

"How good?"

"Fever two days. No chills," said Dr. Causey. "Thirty-nine point five." Then, turning to me, he said, "We have to get right to work on this. The virus loses its virulence rather rapidly after the blood is drawn. We inject the blood into the brains of baby mice. If half the mice die, we are sure the patient had in his blood something fatal to mice. Then we inject a suspension made from the brains of those test mice into the brains of other mice, to perpetuate the virus. We can tell a great deal about the virus from the way the mice react to it, what their symptoms are, and how long it takes them to die, but we do not really know what we've found until New York examines the samples we send them."

Illustrated by William Bryant

Dr. Causey prepares to inject blood from sick jungle workers into mice. How mice react will reveal much about any viruses present.

He moved a tray of baby mice to the work table. There were eight babies and a nursing female in the tray. The mice — Swiss white mice — are raised in a small building behind the main laboratory, eight to ten thousand being born each month. Those to receive the blood were three days old, still pink and hairless.

Picking them up one at a time with his left hand, Dr. Causey swiftly but carefully injected into the brain of each baby mouse .005 cc. of the blood drawn from the sick boy. He put the mice back into the tray with their wetnurse. The tray was labeled by Mrs. Causey and taken downstairs to a double-screened waiting room. There the mice would be checked three times each day. If they showed any sign of sickness, they would be moved to an isolation ward.

The Causeys spend a good deal of time each day studying the mice they have injected with blood or serum. The creatures' progress toward death is carefully noted. Each morning, seven days a week — "Viruses never take a day off, either," says Dr. Causey — they come to the laboratory between six-thirty and seven in their green Chevrolet. Their first hour or so in the laboratory is spent studying the trays of mice.

Dr. Causey, wearing a face mask to protect himself from the possibly virus-laden dust in the bottom of the trays, takes each tray down, calls off its number, and reports on the condition of the occupants.

"All well . . . . All well . . . . One dead, one down, one showing . . . . All well . . . . All dead . . . . Two dead, two down, four showing . . . . All well . . . ."

Mrs. Causey does the bookkeeping required.

The dead mice are lifted from the trays with tweezers and dropped into a container for burning. Some of the sick mice are set aside to be sacrificed. Out of their brains will be made the suspension which, injected into other mice, keeps the virus strain going. These sacrificial mice are put in sterile plastic containers and taken from the isolation unit to the laboratory.

The technician who prepares the suspension was formerly the Causeys' cook. She proved so good at learning recipes and following instructions that they promoted her.

She pins the mouse to the operating board by thrusting thumbtacks through its paws and nose. She removes the brain with three snips of very sharp scissors, changing scissors with each cut so as to remove the possibility of outside contamination. She lifts the brain into a mortar, grinds it up, mixes in some bovine serum, and puts it in a tube. This mixture is then centrifuged at about four thousand revolutions per minute and desiccated in an old crock which has its bottom filled with acid to absorb moisture. The matter is then

[*Continued on p.* 31]

On the light side

Brain teasers

Curious prices
Inquiring at the hardware store, Jones learned that 1 would cost him 50¢, 12 would cost $1.00, and the price of 144 was $1.50. What product was Jones buying?

Days and dollars
George started with an empty piggy bank. Each day he put into it a penny, a dime, and a quarter. He kept this up until the bank contained an exact number of dollars, not a penny more or less. How many days did this take and how many dollars did the bank finally contain?

Drawings by LoCurcio

Oatmeal-box planetarium

Cylindrical cardboard boxes, of the type at least one brand of oatmeal comes in, can be used for projecting beautiful images of star constellations on the wall or ceiling. Copy the constellation you wish to study on a sheet of thin paper. (You can find star charts in books on astronomy or accompanying an article on constellations in an encyclopedia.) Place the drawing face down on the outside of the bottom of the box. You should be able to see the star dots through the paper. With a nail, punch holes through the box at each dot. These holes form a mirror-image pattern of the constellation, but it will appear normal when projected.

To operate your "planetarium," take it into a dark room and insert a flashlight into the open end. Tilt the flashlight so it shines against the *side* of the box rather than directly toward the holes. This will throw an enlarged image of the constellation on the wall. By turning the box you can study all positions of the configuration.

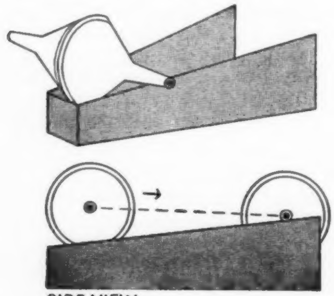
Anti-gravity cone

This curious little toy seems to defy gravity. When it is placed at the bottom of a sloping track, it actually runs uphill!

The toy is a double cone, easily made from two plastic funnels that can be bought at a five-and-ten-cent store. Use rubber cement to stick their rims together. The sloping track is cut from cardboard. You'll have to experiment to get the slope just right, since it will depend on the size of the funnels.

Arrange the track so the two sides are about an inch apart at the lower end, with a width at the other end equal to the length of the double cone. When the cone is placed at the bottom of this track, it slowly rolls to the top.

Observe the cone carefully from the side and you'll see what really happens. As the cone moves "up," the increasing width of the track lowers the cone so that its center of gravity actually moves down.

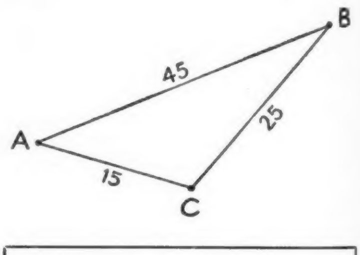


SIDE VIEW

Highway paradox

The map below shows the distances between towns A, B, and C. Two cars start at the same time from A and travel to B at a speed of 45 miles an hour. One goes directly to B, the other goes by way of C. Yet we can prove that the car taking the roundabout way actually gets to B first!

The car taking the direct route obviously arrives at B exactly one hour after starting. The other car reaches C in 15/45 or 1/3 of an hour. From C to B takes 25/45, or 5/9, of an hour, making a total time of only 8/9 of an hour! Can you explain this incredible fact? — George Groth



Answers

CURIOUS PRICES: Jones was buying house numbers.

DAYS AND DOLLARS: After 25 days the bank contained $9.00.

HIGHWAY PARADOX: Two sides of a triangle must have a combined length greater than the third side. Since 15 plus 25 is less than 45, the distances shown on the map cannot be correct.

They hunt the smallest game

(*Continued from p.* 29)

ready to be stored in the laboratory icebox or injected into the brains of other mice.

After a patient who has given blood recovers, he is bled again. The blood is studied for antibodies. Some of it is mixed with that of the original sample of virus. Two more groups of mice then receive injections. One group gets the original virus; the other, virus mixed with antibody. If the mice receiving the original strain die and the mice receiving the virus and antibody survive, then it is shown that the patient did indeed have a virus infection, and the viral matter is sent to New York for identification.

The first unknown virus to be discovered by the Causeys was in the blood of a forty-year-old worker for the Pirelli company who came down with a fever after spending a month in the forest digging out stones for use in top-surfacing a road.

Here is the story of the discovery as told by the Causeys in their annual report for 1955:

> UR 148 was first seen on March 15, prostrate in his hammock on the second day of an illness characterized by severe headache, constant fever and muscle weakness. His temperature was 38.6. Examination of blood smear for malaria was negative. His fever persisted during four days. When he was seen for the collection of convalescent serum after fifteen days he was doing light work but had not regained normal strength. When traced to his native village for a third serum sample five months later he appeared to be in excellent health, and had suffered no subsequent illness.
>
> The acute sample from UR 148 collected on March 15 was inoculated into eight-day-old mice which died on the third day. On passage in adult mice death was produced in four or five days. The acute serum was negative for neutralizing antibodies for [the] virus, which the third sample taken five months later neutralized in the mouse protection test.

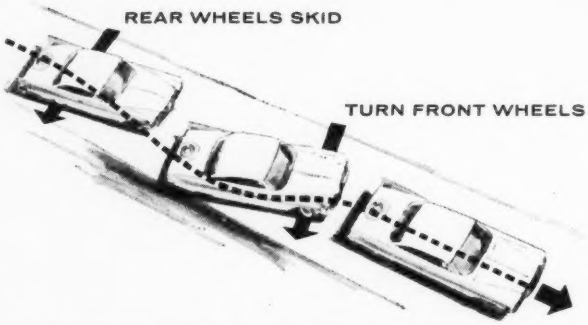
So, dryly and succinctly, wrote the scientists of an important discovery.

The practice, as I have mentioned, is to name viruses for the localities in which they are found. This strain having been discovered on the rubber plantation, the Causeys offered to name it Pirelli, but the company management declined the honor; ultimately the virus was called after the forest in which it thrived, the Oriboca.

[*To be concluded in* SW *April* 21]

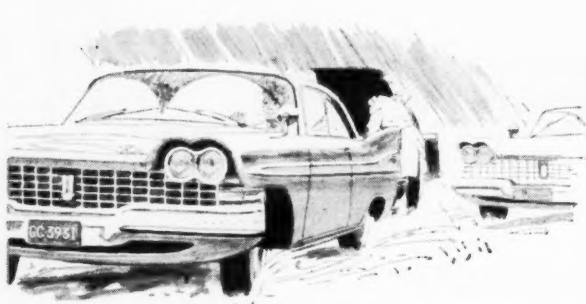
How to be a better driver than most people

These tips from the experts will help you be one of the smart drivers on the road.



PULL OUT OF SKIDS by turning wheels in direction of the skid while you feed gas gently. *Don't* hit brakes. In Can Do cars, Torsion-Aire Springing helps prevent skids, especially on turns, by holding wheels firmly on the road, keeping car level.

SLOW DOWN ON HILLS by "pumping" brake pedal slowly. This prevents overheating and loss of brake-grip. Total-Contact Brakes—exclusive in Can Do cars—fight heat build-up because they grip evenly all around the brake lining.



A WET, SPUTTERING ENGINE will dry by its own heat if you pull off to side, go into Neutral, and feed it gas. Can Do engines are built with completely weatherproof ignition system—keep going in almost any kind of wet weather.

WHEN HE WON'T LOWER HIS BRIGHTS, stare at right shoulder of road till he's past. You'll always dim *your* lights in a Can Do car with Automatic Beam Changer. It lowers beams when car approaches, raises them when it's past.

MUDBOUND OR SNOWBOUND? Make a little path for the wheels by rocking back and forth a few times. In slippery spots like this, Chrysler Corporation's Sure-Grip Axle feeds power to the wheel with most traction, helps pull you out.

Good driving's easier in a Can Do car from Chrysler Corporation. Find out for yourself. Ask Dad to stop by the dealer's with you so both of you can take a drive in the "Cars that Can Do what they look like they can do."

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Modern references and textbook 'tools'

The United States Atomic Industry, a publication prepared for use at the Second International Exhibition of the Peaceful Uses of Atomic Energy, September, 1958, at Geneva, Switzerland, is now available through the Nuclear Standards Board, American Standards Association, Inc., 70 E. 45 St., New York 17, N.Y.

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How to do it

Archimedes' principle and bubbles

When students think of flotation, they usually think of ships and the ability of solid objects to float in liquids. Archimedes' principle, of course, applies to fluids, a term that includes gases as well as liquids. Students should realize that the dirigible and blimp float in air just as surely as a ship floats in water. You can use experiments with gas bubbles to show the application of the principle of flotation to gases.

First, let's blow bubbles with illuminating gas. Prepare a bubble solution by dissolving soap scrapings in water (or use the prepared solution obtainable in a toy store). A little glycerine added to the solution will "toughen" the bubbles so they can, for example, be bounced from a felt hat.

To blow bubbles with illuminating gas, attach a length of hose to a gas outlet. The bubble pipe can be a thistle funnel with a shortened stem. Attach the hose to the stem. Dip the funnel opening into the soap solution so that a film forms over the mouth. Then turn on the gas. You should be able to blow fair-sized bubbles this way. When the bubbles are released from the pipe, the weight of the contained gas plus that of the soap film is less than the weight of the air displaced. So the bubble will rise in the air. If you attach a candle to the end of a yardstick and ignite the bubbles as they rise, they will burn quietly and quickly. (As a precaution against the possibility of burning someone, be sure the bubbles are well above the level of your head when you ignite them. And, of course, see that the room is well ventilated.)

Bubbles blown by mouth will generally sink in still air, since they weigh more than the air they displace. How fast they sink will depend largely on the amount of carbon dioxide they contain. If you take a deep breath and immediately blow a bubble, the bubble will sink slowly in the air. If, however, you continue to exhale and use your last bit of breath to blow a bubble, that bubble will sink more rapidly. Explain to students that this is due to the fact that the first bubble you blew used air from your trachea and mouth. This air was not in contact with your lungs and therefore contained little carbon dioxide. Air used to blow the second bubble had been in contact with your lung tissue. Much of the oxygen had been replaced by heavier carbon dioxide.

An air bubble floating in carbon dioxide makes a rather startling demonstration. Put some dry ice in the bottom of a large battery jar. (To prevent "burns," of course, you should wear gloves and handle the dry ice with tongs or forceps.) Allow the gaseous carbon dioxide to practically fill the jar. Test the level of the carbon dioxide with a burning splint. (It will go out when in carbon dioxide.) Now allow an air-filled soap bubble to fall into the mouth of the jar. Ask students to note how it floats on the invisible carbon dioxide (Fig. 1).

You can blow bubbles filled with carbon dioxide by placing some dry ice in the bottom of a test tube. Shape some wire into a coil and force the coil to the bottom of the test tube to hold the dry ice in place. Invert the test tube and insert its mouth into a bubble solution. Remove the tube. The escaping carbon dioxide will blow a bubble (Fig. 2). Have students note the behavior of such bubbles when they are released in the air. Ask students how the bubbles will behave in the jar of carbon dioxide.

— THEODORE BENJAMIN

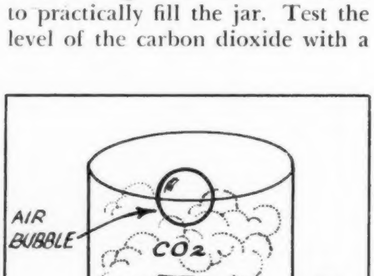

Fig. 1

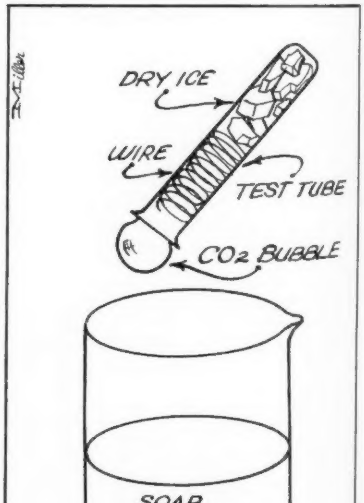

Fig. 2

Shop talk

To some biology students the classification of animals can be dull. But John Maxwell, science teacher at Chautauqua (N.Y.) Central School, has found a way to breathe life into the subject, make it more meaningful, provide a little fun, and at the same time test the ability of students to use what they have learned.

After the class has studied classification, he often takes them on an imaginary trip to another planet. There they meet and must try to classify strange animals, using the characteristics and the classification scheme accepted today. Here is a sample:

A trip to planet Earth XIX

Directions: Read each paragraph and then answer the question that follows it.

1. As we approached Earth XIX in Galaxy 722, huge creatures with giant transparent-membrane wings flew up to meet our spaceship. The expedition's zoölogist classified them as to the most likely phylum. *What did he record?*

2. Since the advance television was not able to observe the number of legs on the creatures, we could not accurately classify them any further. However, our entomologist did suggest that the creatures probably belonged to one of three common orders of animals. *Name the three orders he suggested.*

3. A day or so later, the crew was able to capture several of the beasts. As we dissected each one, we were shocked to find they contained large notochords. *Now, to what phylum do they belong?*

4. We found that they all contained eggs and immature young. We spent days looking for the males, which we never found. The embryologist concluded that they must reproduce as do summer aphids back on Earth I. *What is the name of this fatherless type of reproduction?*

5. Though these creatures had no eyes, they never flew into any object by accident. They seemed to be guided by sound impulses. *Classify as to class and order.*

6. We put on our oxygen helmets and ventured out of the ship into what appeared to be a tropical jungle. Soon we heard the roar of many wings. As we looked into a clearing we saw animals, with bright orange cephalothoraxes and two pairs of antennae, flying around. *Classify as to phylum and class.*

7. Several days later we stumbled across what appeared to be the most successful creatures on the planet. They were the size of hogs, and each had eight legs. *Classify as to class.*

8. We were startled as we gazed at their beautiful homes, built between the walls of what we called Rainbow Canyon. The colorful symmetrical designs were made out of shingle-like plates. Where did they ever get such beautifully colored plates? We did not have to wait long for the answer. We discovered several of the eight-leggers stripping the plates from the large wings of a six-legged creature. They took the plates up to their homes and hung them to produce the designs. *Classify the shingle-winged animals as completely as possible.*

9. Upon further exploration, we found that the eight-legged creatures made large nets from ropelike material secreted from their bodies. These nets were used to capture food. We were astounded to find some huge hot-dog-shaped animals hanging helpless in the nets. We cut some down and found they possessed scales and had bones. *These animals could belong to any one of three classes. Name the three.*

10. Upon further investigation we found they had lungs and were cold-blooded. *Continue to classify.*

About this time we received orders to return to Earth I. Thus the adventure ended.

Answers

1. Arthropoda.
2. Hymenoptera (e.g., bees), Diptera (e.g., flies), and Odonata (e.g., dragonflies).
3. Chordata.
4. Parthenogenesis.
5. Mammalia — Chiroptera.
6. Arthropoda — Crustacea.
7. Arachnida.
8. Arthropoda — Insecta — Lepidoptera.
9. Pisces, Reptilia, or Aves (fish, reptile, or bird).
10. Reptile.

The teacher's stake in The National Defense Education Act of 1958

By Herbert A. Smith

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■ One of the purposes of the National Defense Education Act is to strengthen instruction in science, mathematics, and modern foreign languages. The part of the Act which most directly concerns secondary and elementary school teachers is Title III. A considerable amount of money has been set aside for the improvement of instruction in science, mathematics, and modern foreign languages. The funds are limited, however, as to the purposes for which they may be used. The funds provided may be used to purchase equipment and instructional materials but not instructional supplies. Audio-visual aids and printed matter, other than textbooks*, are included in instructional materials. Some of the money may also be used to provide minor remodeling of laboratory or other space used for such equipment or materials.

The NDEA offers the classroom science teacher an excellent opportunity to demonstrate initiative and imagination. As stated, one of the intents of this law is to upgrade classroom instruction. The classroom teacher is the person who will determine just how effective the program becomes.

The actual plan of operation will vary considerably among the States and Territories. As a basis for obtaining funds which will be used to operate the program, each State or Territory must submit a plan which is, in effect, the blueprint for the operation within that State or Territory. The Law also provides that each State must establish principles of priority, which will determine the order in which projects are to be undertaken. The nature of these priorities will vary in the respective States. They may be priorities established after consideration by the State of such factors as the State's current educational system, relative needs of the local schools, or needs of the State as a whole on different grade levels.

In order to proceed intelligently, the teacher interested in developing a project that will qualify under the Act should attempt to familiarize himself insofar as possible with the details of the State Plan for his State. Projects should be developed in terms of this Plan, since the approval of a specific project will depend upon the State Plan, the standards established by the State for the acquisition of equipment, and the application of the principles of priorities. In some States, half the cost of equipment or materials for instruction or for minor remodeling projects, which are approved by the State, will be transferred to local schools either in advance or as a reimbursement. In some cases the money will be advanced to the local schools but will be accounted for in the auditing procedures. Some States are also following the principle of reimbursement on the basis of need, i.e., projects which are approved will be supported on a variable basis, depending on the particular district's need for financial assistance.

One of the additional requirements of the Law is that the States must establish standards on a State level for laboratory and other special equipment and materials. Most States intend that these lists will be suggestive only, and that items not on the list will be eligible for reimbursement if they can be justified by the programs offered in the school. One restriction in the Law which must be kept in mind by teachers is that supplies cannot be reimbursed. As a general guide to what is meant by supplies, it can be said that materials which are ordinarily consumed in use, such as chemicals or chalk, are not eligible for reimbursement. The length of use is another criterion. Ordinarily, materials are thought of as being used for a period longer than one year. Printed materials other than textbooks may be purchased and be eligible for reimbursement.

In order to participate effectively in the program, the enterprising science teacher should have an up-to-date and accurate inventory of all equipment and materials presently available. The feasibility of a particular project may depend in part on what is already available. Certainly, administrators and State co-ordinators may want to know whether or not equipment being requested duplicates existing equipment. An accurate inventory and a well-maintained classroom and storeroom are likely to be assets when the question of approval of specific projects arises. Advice to the individual science teacher might be summarized as follows:

1. If possible, know your State Plan and submit projects that are in harmony with the priorities established by the State.
2. Have a complete and accurate inventory of the equipment available.
3. Decide what you need most or what will make the greatest contribution to your instructional program.
4. In consultation with your local administration, write up a specific proposal in terms of the State Plan. After approval by the local authorities, the project proposal should be transmitted as soon as possible to the State Department of Education. Requests having equal priorities in terms of intrinsic merit or in terms of the priorities system established may be taken in chronological order. Thus, it will pay to get the request in early.
5. Be sure that your project requests support for a program that meets the definitions established for equipment, materials and/or remodeling.
6. If the State agency has issued instructions and/or application forms, follow the instructions implicitly and complete the application form in all details if you handle such matters.

*"Textbook" means the book(s) dealing with a definite subject of study, appropriate for use at a specified level of instruction, and used as a principal source of study material for a given class or course and a copy(ies) of which is (are) expected to be available for the individual use of each pupil. Workbooks and laboratory and other manuals for the individual use of each pupil are classified as textbooks.

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